POWER PLANT ENGINEERING

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New Station for Detroit Edison Co.

EACH FURNACE BOTTOM IS PROTECTED BY TWO WATER SCREENS WHICH ARE EQUIPPED WITH FEED WATER REGULATORS AND WHICH DISCHARGE STEAM INTO THE MAIN BOILER DRUMS. BY A. K. BAK AND R. B. PURDY

CONTINUED increase in demand for electric energy in Southeastern Michigan has made it necessary for The Detroit Edison Co. further to increase its system generating capacity. This need will be filled by the Trenton Channel Plant now being constructed on Slocum's Island below the village of Trenton which is about 18 mi. south of Detroit. The new station, which will be the fourth steam plant in the system, will embody several new features such as pulverized coal, stage feed water heating, an outdoor switching station and direct current generators for driving station auxiliaries, making the source of auxiliary energy absolutely independent of the main system.

This plant, located on the Detroit River, is served by two railroads. It is at the southern end of a double circuit 120,000-v. transmission line, which forms a rough semicircle about Detroit as a center and has at its northern extremity the Marysville plant. The station has been planned for an ultimate capacity of 300,000 kw., the first half of which is now under construction.

At the intake on the river front is located a screen house containing six inclined traveling screens for keeping trash and refuse from entering the condensers. The intake tunnel is carried under the boiler room to a tunnel running lengthwise under the condenser room. The overflow tunnel is brought out under the electrical mat to a channel west of the plant. A recirculating canal located over the intake tunnel makes it possible to divert part of the overflow back in front of the traveling screens thus providing a convenient means for fighting river ice. A movable weir located in the overflow canal allows the level to be raised high enough to force the water back through the recirculating tunnel.

Between the screen house and the boiler room are located the coal unloading, breaker and coal preparation houses, the preparation house being separated from the boiler house by a 30-ft. aisle.

Plans call for a boiler house which will accommodate nine boilers arranged in three batteries of three boilers each, eight of which are being installed at present. They

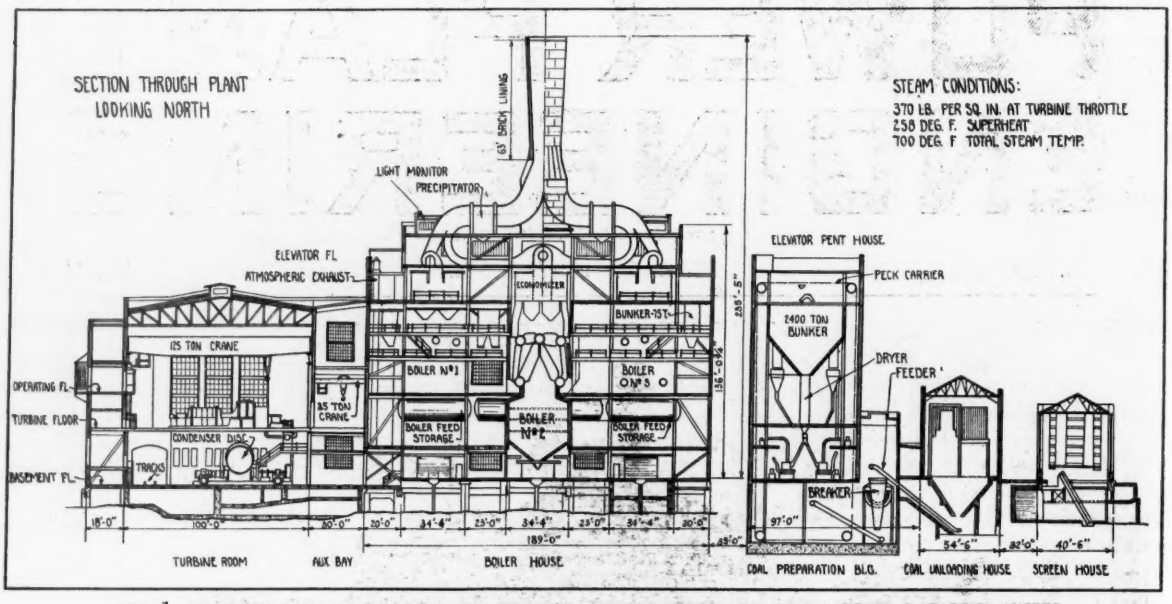


FIG. 1. SECTION THROUGH THE PLANT SHOWING THE RELATION OF THE VARIOUS BUILDING UNITS

are Stirling Class "W" boilers and have the same general tube arrangement as those at Marysville though slightly larger, the effective heating surface of each boiler being 29,087 sq. ft. Each boiler is equipped with twin triple "U" tube Babcock and Wilcox superheaters, having a total heating surface of 6070 sq. ft.

Above each boiler are two, two-pass Babcock & Wilcox, duratex-type, steel-tube economizers each containing 9492 sq. ft. of heating surface or 18,984 sq. ft. per boiler. The draft necessary to draw the flue gases through the boiler and economizer is provided by one motor-driven Sirocco induced draft fan per boiler. One self-supporting brick-lined steel stack serves three boilers.

Water Screens Are Virtually Separate Boilers

Furnace bottoms are protected by tube screens but instead of making these part of the boiler circulating system as has been done in many other pulverized fuel installations the screens are essentially two independent boilers. These screen boilers having a total effective heating surface of 1220 sq. ft. per boiler are fed through Copes regulators from the same line that feeds the main boiler and the steam is discharged into the steam space of the center drum of the main boiler before going to the superheater.

FIG. 2. RAYMOND PULVERIZERS ARE USED IN THE PREPARATION OF THE PULVERIZED COAL

The first section of the turbine-room will contain three General Electric Co. 21-stage, 50,000-kw. turbines each coupled to a 62,500-kv.a., 1200 r.p.m., 12,200-v. generator. The turbo-generators are arranged cross-wise in the turbine room, which has a span of 105 ft. and 11 in. Steam extracted from the fourteenth, seventeenth and nineteenth stages is used for feed water heating; steam from the fourteenth stage is also used in evaporators for make-up water. Each main unit has two combination hotwell and boiler feed pumps, one driven by a direct-current motor and the other, which is to be used only as a spare, by a steam turbine.

All auxiliaries are electrically driven, with the exception of one steam driven general service pump and the steam driven combination pumps. All steam driven pumps are for emergency use only. Alternating current is used throughout the coal preparation room and also for ash sluicing pumps, air compressors and station lighting; the rest of the auxiliaries are driven by direct current. To furnish auxiliary energy, one 4000-kw. d.c. unit will be installed for each main machine, the unit consisting of two General Electric direct current generators mounted on the same shaft and driven through reduction gearing by a De Laval compound turbine. The alternating current auxiliary energy may be furnished either by two 2000-kw. Westinghouse turbo-alternators or from a 23,000-v. line brought back from a substation located about 4 mi. from the plant. The house service machines have their own condensing and auxiliary equipment.

Generator voltage is stepped up in outdoor single phase transformers from 12,200 to 120,000 v., at which pressure all the energy leaves the plant. The high tension station bus as well as all high tension switching equipment is located on an outdoor switch mat west of the turbine room.

Design Ratios

Steam Conditions

370 lb. per sq. in. gage at turbine throttle.
258 deg. F. superheat.
700 deg. F. total temperature.

Boiler surface in all cases is total of main boiler and tube screen boiler surfaces.

Ratio of superheater surface to boiler surface	20.0 %
Ratio of economizer surface to boiler surface	62.5 %
Square ft. of boiler surface per kw	1.62
Cubic ft. combustion volume per kw	1.34
Boiler horsepower per burner	189.4
Kilowatt capacity per burner	1170.
Cubic ft. combustion volume per boiler hp	8.3
Pounds of coal per hr. at 400 per cent rating per cu ft. combustion volume	1.71
Total number of air openings per furnace	168.
Square ft. of opening per burner	6.5

Coal Handling and Preparation

All coal is received by rail and after being weighed on track scales, the cars go either to the coal unloading pits or to storage, where they are unloaded by means of locomotive cranes. Coal taken from storage is loaded in railroad cars by means of the cranes and after being weighed on the track scales, is brought to the unloading pits. The scale house, therefore, has a complete record of all the coal received from outside as well as the amount delivered to the power house each day. The unloading hopper is arranged with two tracks and it is large enough to accommodate two cars on each track. Over one of the tracks is installed a Brown Hoist unloader, to be used primarily for unloading frozen coal.

From the bottom of the unloading hopper the coal is conveyed by one of two 42-in. apron conveyors to the hopper of a Bradford breaker. The conveyors have a 30-deg. incline and a capacity of 160 T. per hr. each, at a speed of 24 ft. per min.

At present only one Bradford breaker will be installed. It consists of a cylinder 12 ft. in diameter and 22 ft. long rotating at a speed of 14 r.p.m. with a capacity of 315 T. of coal per hr. The inside of the cylinder has a system of lifting shelves and deflectors, which when rotated lift the coal to a certain height from which it drops and breaks on hitting the bottom. The deflectors are arranged so as to push the coal from the head end towards the tail end of the breaker. Perforations in the breaker shell allow coal of 1¼ in. size to drop through into a hopper underneath the breaker.

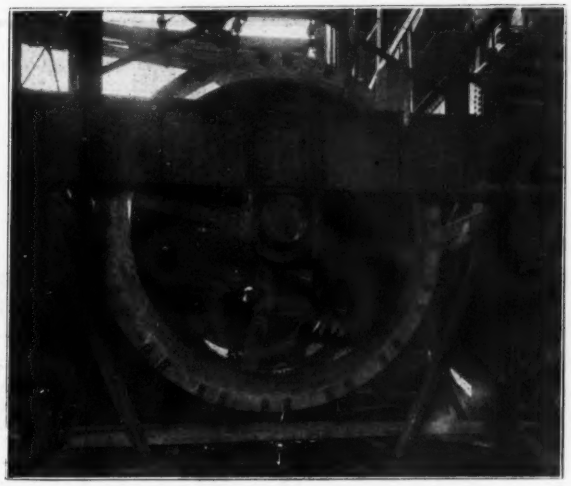


FIG. 3. ROTATING BARREL AND SCREEN OF THE COAL BREAKER

Unbroken coal, together with foreign material which cannot be broken, is discharged at the end of the breaker and elevated by a bucket elevator to a picking belt, from which an operator can remove all tramp iron, wood and other refuse. The unbroken coal is delivered by the belt to the breaker hopper and passes through the breaker a second time. The process of breaking the coal gives rise to a great amount of dust and in order to confine this as much as possible the breaker has been enclosed in a metal casing and a fan arranged to maintain a pressure slightly less than atmosphere in the casing.

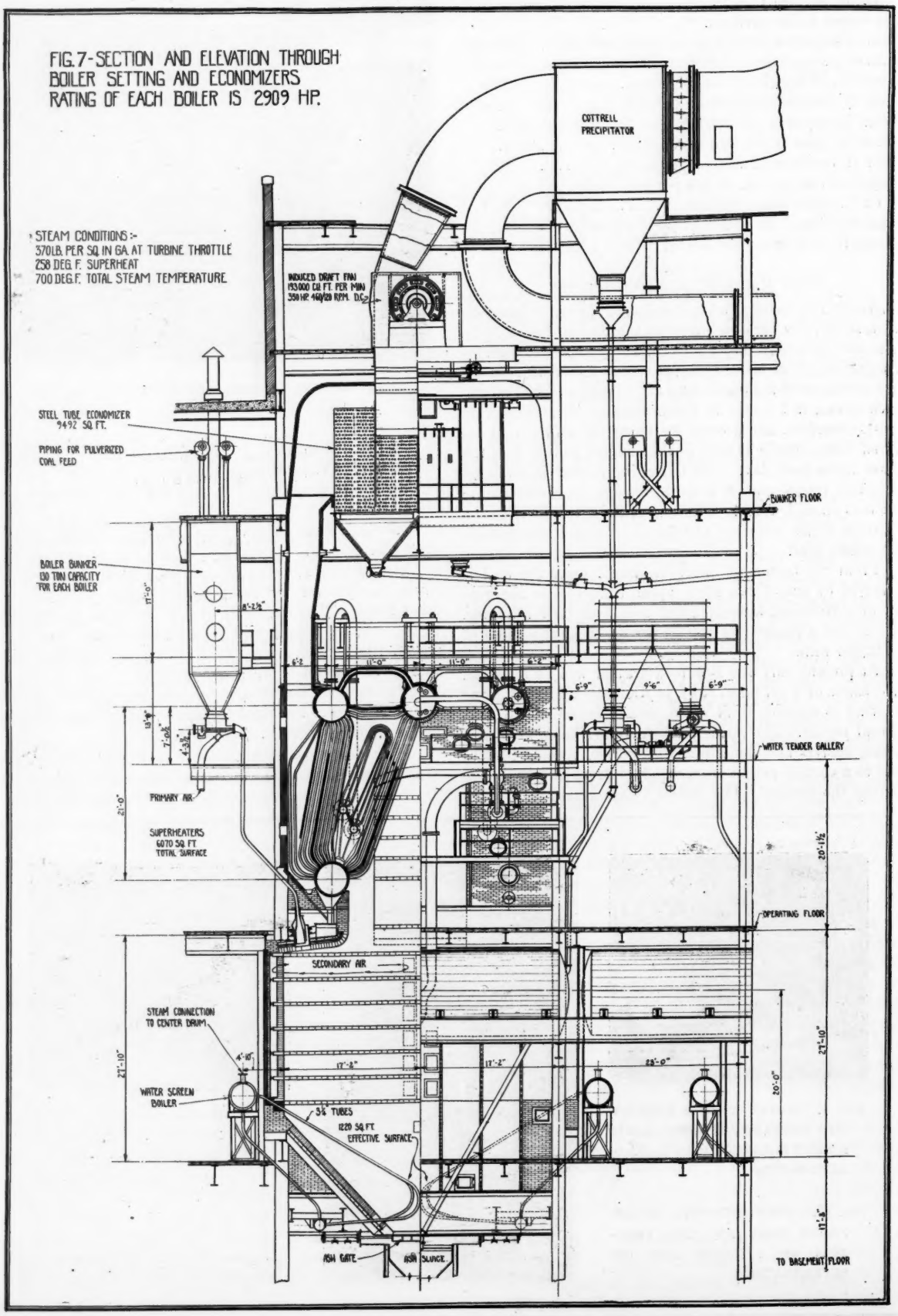
After being crushed, the coal is transported by two short apron conveyors to two bucket elevators, each of 160 T. capacity and elevated by them to a 36-in. Robins belt

FIG. 4. WATER SCREENS PROTECT THE FURNACE BOTTOMS. EACH SCREEN IS ESSENTIALLY A SEPARATE BOILER

FIG. 5. VIEW SHOWING BOILER FRAME WORK AND THE ERECTION OF A BOILER AND ITS SUPERHEATER

FIG. 6. EACH BOILER IS EQUIPPED WITH TWO, TWO-PASS STEEL TUBE ECONOMIZERS EACH OF WHICH CONTAINS 9492 SQ. FT. OF HEATING SURFACE OR 18,984 SQ. FT. PER BOILER WHICH MAKES A RATIO OF ECONOMIZER SURFACE TO BOILER SURFACE OF 62.5 PER CENT

FIG. 7 - SECTION AND ELEVATION THROUGH BOILER SETTING AND ECONOMIZERS RATING OF EACH BOILER IS 2909 HP.



conveyor above the raw coal bunker. This belt discharges over a Ding's magnetic pulley, which removes all tramp iron, on to a reversible shuttle belt conveyor, making possible distribution of coal over the entire length of the bunker. The capacity of the two belts is 320 T. per hr. at a belt speed of 325 ft. per min. The raw coal bunker occupies the upper portion of the coal preparation house and is of rigid steel construction lined with concrete only on its sloping sides. It has a capacity of 2400 T. which constitutes the main storage of fuel in the plant.

Coal Will Not Ordinarily Be Dried

It is expected to operate without drying the coal most of the year. The coal used comes from fields in West Virginia and Kentucky and does not ordinarily carry an excess of surface moisture. Wood driers of an improved design will be installed just below the raw coal bunkers to take care of abnormally wet coal. The driers will be heated by passing steam bled from the house service turbines through coils built in the coal lane of the drier. It is also planned to draw hot air from the boiler room to the driers through a duct connecting the boiler room with the coal preparation house.

Dried coal is fed by gravity to the pulverizer mills located on the basement floor of the coal preparation house. In the first section there will be 14 mills. The coal will be pulverized so that 75 per cent will pass through a 200-mesh screen, 90 per cent through a 100-mesh screen and 99 per cent through a 50-mesh screen. Under these conditions each mill will have a capacity to pulverize 6 T. per hr.

Coal which has reached the proper degree of fineness is picked up by exhausters and elevated to cyclone separators, one for each mill. The mill, fan, separator and piping make a close system but as part of the system is under a vacuum there will always be some air leakage, therefore a vent line is installed as close as possible to the neutral point in the system.

Under each of the two rows of cyclone separators are two 16-in. diameter screw conveyors which collect the pulverized coal to a bin over three Fuller-Kinyon coal pumps. Each of these pumps has a capacity to pump 50 T. of coal per hr. to the boiler bunkers through 8-in. pipe lines. Each Fuller-Kinyon pump requires approximately 350 cu. ft. of free air per min. at 70 lb. gage pressure. This compressed air is furnished by an 825 cu. ft. per min. duplex two stage Bury compressor. Reserve capacity is obtained from the main station compressed air system.

Both of the two pipe lines of the double system of coal piping over the boiler bunkers can be fed by any one of the three coal pumps and all bunkers can be filled from either of the two pipe lines. The valves controlling the distribution of coal to the bunkers are operated by pneumatic cylinders, admission of air to the cylinders being remotely controlled from the coal preparation house. A mercoid switch mounted on the side of each valve operates a signal on the control board indicating the position of the valve.

Near the top of each boiler bin is a paddle which is arranged to operate a mercoid switch on top of the bin. This switch in turn operates a high bin signal in the coal preparation house. The switch which is operated when the bin becomes full not only indicates this condition in the coal preparation house but also automatically closes the valve through which the bin is being filled and allows the coal to pass on to the next bunker.

All necessary instruments and meters will be installed to give a complete record of actual cost of preparing the fuel over any length of time.

Coal storage bins of 130 T. capacity per boiler are of steel construction riveted and welded throughout and tested with water to insure tightness. Fastened to the bottom of them are duplex Lopulco feeders, driven by adjustable speed direct current motors. Each feeder is equipped with a clutch so that either of the two feeders may be disengaged from the motor without stopping the other. The speed of the motor is controlled by a 70-point controller giving a speed range of 300 to 1200 r.p.m. Eight feeders per boiler (four on each side) feed coal to 16 Lopulco, 4-in., right-angle, fish-tail burners. About 10

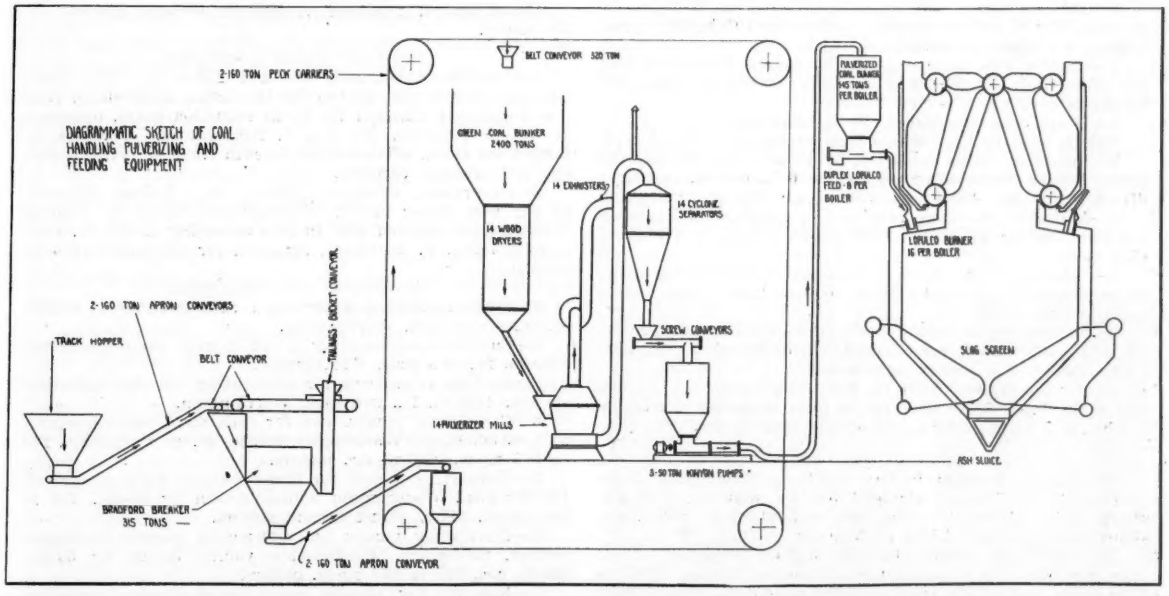


FIG. 8. SKETCH SHOWING THE GENERAL METHOD OF COAL HANDLING AND PREPARATION

Mechanical Equipment Used at Trenton Channel

Boiler room for nine boilers, 189 ft. by 165 ft. 8 in.
Turbine room for three units, 105 ft. by 11 in. by 180 ft.

Coal Handling and Preparation Equipment

2—Long apron conveyors built by Link-Belt Co., 42 in. wide, 160 T. per hr. capacity; driven by 25-hp., 1200 r.p.m., 2200-v., a.c. slip ring motor.

2—Short apron conveyors built by Link-Belt Co., 42 in. wide, 160 T. per hr. capacity; driven by 25-hp., 1200 r.p.m., 2200-v., a.c. slip ring motor.

1—Bradford breaker, built by Pennsylvania Crusher Co., 315 T. per hr capacity; driven by 150-hp., 540 to 720 r.p.m., 2200-v., a.c. slip ring motor.

1—Bucket elevator, built by Chain Belt Co., 24 in. wide buckets.

1—Belt conveyor, built by Robins Conveying Belt Co., 24 in. wide belt.

2—Peck carriers built by Link-Belt Co., 36 in. wide, 160 T. per hr. capacity; driven by 40-hp., 900 r.p.m., 2200-v., a.c. squirrel cage motor.

1—Belt conveyor, built by Robins Conveying Belt Co., 36 in. wide, 320 T. per hr. capacity; driven by 10-hp., 900 r.p.m., 2200-v., a.c. slip ring motor.

1—Shuttle belt conveyor, built by Robins Conveying Belt Co., 36 in. wide, 320 T. per hr. capacity; driven by 10-hp., 900 r.p.m., 2200-v., a.c. slip ring motor.

1—Ding's magnetic pulley, 36 in. diameter.

Driers, built by Combustion Engineering Corp., wood type.

9—Pulverizer mills furnished by Combustion Engineering Corp., 6 rolls, lowside, air separation, 6 T. per hr. capacity; driven by 100-hp., 450 r.p.m., 2200-v., a.c. slip ring motor.

9—Mill exhauster fans, furnished by Combustion Engineering Corp. driven by 60-hp., 1200 r.p.m., 2200-v., a.c. squirrel cage motor.

4—Screw conveyors, built by Combustion Engineering Corp., 16 in. diameter; driven by 25-hp., 600 to 1200 r.p.m., 2200v., a.c. slip ring motor.

3—Fuller-Kinyon pumps, built by Fuller Engineering Co., 10 in. diameter, 50 T. per hr. capacity; driven by 60-hp., 1200 r.p.m., 2200-v., a.c. squirrel cage motor.

1—Air compressor, built by Bury Compressor Co., duplex two stage type, 825 c.f.m., 75 lb. gage pressure; driven by 185-hp., 225 r.p.m., 2200-v., a.c. synchronous motor.

Burning Equipment

64—Duplex Lopulco feeders, built by Combustion Engineering Corp., diameter air inlet 5½ in., diameter coal discharge 4 in.; driven by 2-hp., 300 to 1200 r.p.m., 240-v. d.c. shunt wound motor. Eight feeders per boiler.

16—Feeder air blowers, built by Buffalo Forge Co., 55 in. diameter, 6500 c.f.m. capacity; driven by 30-hp., 1200 to 1600 r.p.m., 240-v., d.c. compound wound motor. Two blowers per boiler.

128—Lopulco burners, built by Combustion Engineering Corp., 4 in. diameter coal inlet, right angle, fish tail type, 16 per boiler.

Boilers, Superheaters, Economizers and Tube Screens

Eight class W, type 53 Stirling boilers, built by Babcock & Wilcox Co., 29,087 sq. ft. effective heating surface, 3¼ in. diameter tubes, designed for 416 lb. pressure, 255 deg. F. superheat, twin triple "U" tube B. & W. superheaters, 6070 sq. ft. heating surface.

Tube screen at bottom of combustion chamber, 3¼ in. diameter, No. 6 BWG tubes, 1220 sq. ft. effective heating surface, made by Babcock & Wilcox Co. Two Duratex B. & W. economizers per boiler, 2 in. diameter No. 6 BWG tubes, 9492 sq. ft. heating surface per economizer.

Stack and Draft Equipment

One brick lined Venturi shaped steel stack for each three boilers, supported on building steel; 199 ft. 4 in. above burners, 21 ft. inside diameter at top, 15 ft. inside diameter at throat.

1—Double inlet American Blower Co. Sirocco induced draft fan per boiler, rated at 193,000 c.f.m., 7.15 in. static pressure, driven by 350-hp., 460 to 120 r.p.m., 240-v. d.c. motor.

2—Cottrell precipitators for three boilers, to remove refuse from flue gas.

Pumps, Feed Water Heaters, Etc.

De Laval combination boiler feed and hotwell pumps. Boiler feed pumps six stage, 1300 g.p.m., 1090 ft. total head. Hotwell pumps, single stage, 1500 g.p.m., 180 ft. head. Three pumps driven by 700-hp., 1200 to 1000 r.p.m., 240-v. d.c. motors and three by single stage De Laval turbines.

General Service pumps, De Laval two stage, 2400 g.p.m., 307 ft. head. Two pumps driven by 240-hp., 1700 to 1200 r.p.m., 240-v., d.c. motors, one by single stage De Laval turbine.

3—Ash sluicing pumps, single stage, 2000 g.p.m., 70 ft. head De Laval, driven by 60-hp., 1200 r.p.m., 2200-v. a.c. motors.

3—Griscom-Russell, condenser type, stage heaters for each main turbo-generator, each heater has 2622 sq. ft. of heating surface.

1—Griscom-Russell Reilly evaporator and condenser for evaporated make-up for each main turbo-generator unit, to evaporate 6625 lb. of raw water per hour.

Main Turbo-Generator, Exciter and Air Cooler

3—Generators, 62,500-kv.a., 1200 r.p.m., 60-cycle, 3-phase, 12,200-v., General Electric Co., driven by 21-stage, horizontal, Curtis turbines operating at 375 lb. pressure, 258 deg. F. superheat. Designed for steam extraction from 14, 17, 19 stages, shaft driven exciter, 250-kw., 250-v.

Closed system generator ventilation, General Electric Co. air cooler.

Auxiliary Turbo-Generators

3—Generators, two-unit, 4000-kw., 250-v., d.c., 360 r.p.m., General Electric Co., driven by De Laval, multi-stage, compound turbines, through De Laval reduction gears, operating at 390 lb. pressure, 700 deg. F. temperature. Turbines arranged for steam extraction at seventh stage or between high and low pressure turbines.

2—Generators, 2000-kw., 2300-v., a.c., 3-phase, 60-cycle, 66 per cent power factor, Westinghouse, driven by 12-stage Westinghouse parallel flow turbine operating at 385 lb. pressure, 255 deg. F. superheat, arranged for extraction at 5 lb. pressure.

Condensers and Auxiliaries

3—Surface condensers for main turbo-generators, 52,000-sq. ft., single pass, Worthington.

3—Surface condensers for direct current turbo-generators, 7500-sq. ft., two pass, Worthington.

2—Surface condensers for alternating current turbo-generators, 4100-sq. ft., two pass, Worthington.

6—Circulating pumps, two for each main turbo-generator unit, 60,000-g.p.m. Worthington volute, driven by 325-hp., 255 to 175 r.p.m., 240-v., d.c. motors.

3—Circulating pumps for direct current turbo-generators, 10,000-g.p.m., Worthington volute, driven by 60-hp., 435 to 215 r.p.m., 240-v., direct current motors.

2—Circulating pumps for alternating current turbo-generators, 8000-g.p.m. Worthington volute, driven by 60-hp., 220-v., a.c., 720 to 450 r.p.m. motors.

1—Rotative dry vacuum pump for each main turbo-generator, 30 in. by 18 in. vertical Laidlaw-Dunn-Gordon, driven by 66-hp., 240-v., d.c. motor.

3—Rotative dry vacuum pumps for direct current turbo-generators, 21 in. by 14 in. horizontal Laidlaw-Dunn-Gordon, driven by 25-hp., 240-v., d.c. motors.

4—Worthington No. 6 hydraulic vacuum pumps for alternating current turbo-generators.

2—Vacuum supply pumps for hydraulic vacuum pumps, 1000-g.p.m. Worthington, driven by 25-hp., 1800 r.p.m., 220-v., a.c. motors.

3—Hotwell pumps for direct current turbo-generators, 150-g.p.m. two stage, Worthington, driven by 30-hp., 1600 to 1200 r.p.m., 240-v., d.c. motors.

2—Hotwell pumps, 80-g.p.m. Worthington, driven by 15-hp., 1800 r.p.m., 230-v., a.c. motors.

Miscellaneous Mechanical Equipment

1—Bury air compressor, 825 c.f.m., 125 lb. pressure, two-stage.

Turbine room crane, 125 T., Whiting Corp., 97 ft. 5½ in. span.

6—Inclined Rex traveling water screens, Chain Belt Co.

8—Surge tanks, 10 ft. 6 in. diameter by 34 ft. 9 in. long; 23,500 gal. each.

1—Toledo track scale, 125 T. capacity.

Consolidated safety valves, Hopkinson gate valves, Diamond soot blower units, Van Stone pipe joints, Crane piping, Bailey air flow, steam flow boiler meters; Bailey multi-pointer draft gages; General Electric electric flow meters; Builders Iron Foundry Venturi meters; Recording gages driven by Warren clocks.

Oil Circuit Breakers

6—132,000-v., 400-amp. outdoor type FHKO-39-72C-F3,

Mechanical Equipment Used at Trenton Channel—Continued

General Electric Co. Full automatic trip free, for 120,000-v. switching.

3—Machine switches, 25,000-v., 4000-amp., bottom-connected. General Electric Co. Type FH-209, 12 in. diameter oil pot., 24-in. stroke for 12,000-v. switching.

DISCONNECTING SWITCHES

12—Disconnect knife switches, T. P. S. T., with ground blades on line side only. Remote hand controlled. Westinghouse type "R" outdoor, 400-amp., 132,000-v., each on fabricated steel stand for 120,000-v. switching.

9—Machine switch disconnect switches, S. P. S. T. lock type, multiple blade, sub-cell mounting, 4000-amp., 25,000-v., hook stick operated. Detroit Edison Co.'s own make.

TRANSFORMERS

9—Main unit transformers, 120,000-v. Y to 12,000-v. delta connected, single phase, 21,000-kv.a., oil insulated, water cooled. One high voltage bushing. General Electric Co.

LIGHTNING ARRESTERS

120,000-v. System. 2 sets of General Electric Co. oxide film arresters on outgoing trunk lines only. (1 set per line.) Four stacks each. General Electric type O. F., form BO, 126,000-v. max., 3-phase, outdoor.

MOTOR-GENERATORS

One Westinghouse 25-kw., 240-v., d.c., to 120 to 170-v., d.c., for control battery charging and stand-by.

Three Westinghouse 7-kw., 240-v., a.c., 3-phase, 120 to 170-v., d.c., for battery charging.

BATTERIES

Four Exide, type M.V.S., 21 plates, 60 cells. For control and emergency service.

per cent of the air necessary for combustion enters the furnace with the coal. This air, drawn through openings in the end walls just below the operating floor, passes upward through the hollow portions of the walls to openings below the center steam drums, where it enters two high pressure blowers per boiler and is blown in with the coal.

All additional air, after passing through the ventilated boiler setting, enters the furnace through staggered openings in the side walls below the arches.

Each of these horizontal ducts has two openings in each end wall through which outside air enters the setting. There is a dividing wall between the two rows of openings in each end wall and another vertical partition in the middle of each side wall. Thus each horizontal duct is divided into four sections, each of which can obtain air from the outside through only one opening, with damper control.

Each duct has fourteen openings into the furnace through the side walls. Thus seven furnace openings are supplied with air by one opening in the end wall. The total number of furnace openings in each side wall is 84 or an average of 10.5 openings per burner. As each opening is 9 in. by 10 in., the total area per burner is 6.5 sq. ft. The bottom part of the end wall below the horizontal ducts is ventilated by air entering at the bottom of the wall.

CONTROL OF FURNACE OPERATIONS

Air drawn into the furnace is controlled by the draft in the combustion chamber, which in turn is regulated by the speed of the induced draft fan and by the position of the dampers in the entrance ports. The regulation of the speed of the induced draft fan is by hand, except on one boiler where the Bailey semi-automatic system of combustion control is installed. This system requires that any desired change in rating be effected by manual operation, either increasing or decreasing the coal feed. The automatic feature then comes into action and adjusts the speed of the induced draft fan so that the correct amount of air necessary for efficient combustion is drawn into the furnace.

Ash from the furnaces is disposed of by sluicing it through a trough located under each row of boilers and separated from the furnaces by air operated ash gates. For the present the ash will be used for filling.

FIG. 9. VIEW SHOWING THE ERECTION OF A MAIN CONDENSER

FIG. 10. OUTDOOR SUB-STATION AT THE TRENTON CHANNEL PLANT

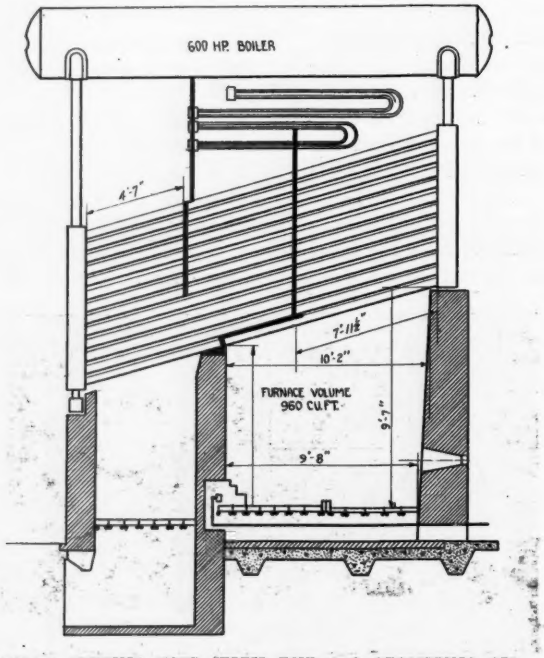
Two batteries of boilers are equipped with Cottrell Precipitators which remove the ash and refuse carried by the flue gases. Two precipitators serve three boilers and are installed in the flues between the induced draft fan and the stack. The precipitators subject the gas passing through them, to a high electrical potential, which polarizes the ash particles and deposits them on grounded plates, from which they are removed at intervals by a shaker arrangement.

Boiler gage boards are located on the operating floor along the north wall of each boiler. They contain the controls for all the Lopulco feeders, induced draft fans, feeder, air blowers and damper control motors. Bailey instruments mounted on the same gage board record steam and air flow, steam temperature and feed water and flue gas temperatures entering and leaving the economizer. Draft conditions in the boiler and economizer and feeder air pressure are indicated by two Bailey multi-pointer draft gages.

Burning Liquid and Gaseous Fuels

EXPERIENCE WITH BURNERS, FURNACE DESIGN AND AIR PREHEATERS
REPORTED BY THE PRIME MOVERS COMMITTEE OF THE N. E. L. A.

ONE OF THE most important questions in connection with mechanical oil burner installations is that of a furnace design to obtain a longer life for the brickwork. Floors that are laid directly upon foundations which have no basement or open space underneath suffer particularly. The fire brick is often melted, all insulating material destroyed and in some cases the concrete base upon which the floor is laid becomes vitrified. In order to avoid this it is necessary to provide an air space under the floor so that air may be circulated. Possibly a dead air space may



BOILER SETTING USED WITH THE GAS ATOMIZING OIL BURNER

give sufficient relief. While the ventilated furnace will increase the life of the brickwork, it is questionable just how far this can be carried without lowering the efficiency of the furnace. Tests indicate that the ventilation of walls by air to the extent, at least, of 10 per cent of that required for combustion, does not lower the furnace efficiency.

PREHEATING OF AIR

Air preheaters in connection with boilers fired with mechanical oil burners seem to offer attractive possibilities. The mechanical burner is easily adapted to forced draft and the passage of highly heated air should offer no difficulties. A heater installation in which the air preheater surface for one boiler was about half the boiler heating surface, cost F. O. B. factory at the rate of somewhat over $1.00 per sq. ft. of the preheater surface. The total installation cost of the preheater, including fans, ducts, etc., was somewhat less than $2.00 per sq. ft. The estimated fuel saving is about 3 per cent.

Test data shows that for a given type of boiler, the most efficient rate of combustion per unit of volume is constant and that the relation between the rate of combustion per unit of volume and boiler efficiency is likewise a constant for any given type of boiler.

One question of considerable importance is the maximum quantity of oil which can be fired per unit of furnace volume without decreasing furnace efficiency. Tests give about 2.5 lb. of oil per cu. ft. per hr. as the maximum that can be fired before the losses from radiation and "unaccounted for" increased in per cent, that is, before a decrease in furnace efficiency occurred. Data from the tests on the boilers at the Savannah Electric Company, show that 4.7 lb. of oil per cu. ft. per hr. may be fired without increasing the per cent losses due to radiation and "unaccounted for."

Both steam and electric-driven liquid fuel pumps are sanctioned by the Fire Underwriters provided that in all cases the fuel oil tank is so located that the oil cannot flow by gravity to the burners and that there is a return oil line.

GAS ATOMIZING OIL BURNER

Gas as an atomizing agent for fuel has at various times been suggested and some interesting work on this subject has been done by the Texas Power & Light Co. Its experience is as follows:

Fuel oil, when burned under steam boilers is usually atomized by steam, air or by mechanical means but no record has been found of the use of natural gas as an atomizing medium. Such a combination has been experimented with under one of the boilers at the East Waco generating station and found to be satisfactory. The saving to be effected by the use of a combustible gas as an atomizing agent, when its cost is approximately the same as oil, is evident when it is considered that at least 1½ per cent of the total steam generated is required for atomizing and that the heat to raise this steam to the temperature of the escaping gases must be robbed from heat generated in the furnace.

Each burner body was tapped at the bottom for a ¾-in. pipe and an atomizing connection made through the tee. The ⅜-in. hole in the burner body, which was formerly the steam atomizing connection, was plugged. At the outer end of the burner atomizing piping connection a 1-in. tee was cut into the line and connection made to bypass the valve body. The 1-in. outlet on the tee was then connected to the gas supply heater while the connections were made to the oil and steam lines in the usual manner. In this way it was possible to change from atomizing with gas to atomizing with steam by simply closing the bypass gas valve and opening the steam valve.

Tests were made under a 6000 sq. ft. B. & W. boiler. The percentage of gas and oil burned was computed on a heating value basis. The gas used during these tests had a specific gravity of 0.650 and a calorific value of from 1000 to 1100 B.t.u. per cu. ft. The oil used was about 25 deg. Baume Texas fuel oil, with the calorific value of about 19,000 B.t.u. per lb. It was found possible to operate at ratings up to 170 per cent with 20 to 40 per cent of the total heat being contributed by the natural gas atomizing medium with as good combustion conditions as with either oil or gas when being used as the sole fuel. During the

tests the oil was weighed, the gas measured by a Foxboro orifice meter and the steam flow recorded by a G. E. flow meter.

Fuel Oil Must Be Heated

It is the practice to heat this grade of fuel oil to 160 deg. F. for steam atomizing but it was found that combustion with gas atomization was not satisfactory until the temperature of the oil was 200 deg. F. or over.

The flame with gas atomization is longer than with steam and ignition occurs at a distance of from 9 in. to 18 in. from the burner tip. It is believed that the ignition would be closer to the burner and the flame shorter with a higher temperature of mixture. It is possible that this higher temperature might be obtained either by heating the oil to a higher temperature or by pre-heating the gas.

With ratings in excess of 160 per cent, the flame became so long that it began to impinge on the front wall of the furnace setting and ratings beyond this point were unsatisfactory. It must be borne in mind that the bridge wall construction of this furnace makes impossible a long flame combustion condition. With the longer furnaces, such as are installed under the other boilers at this station, it is believed that an output of 200 per cent of rating might be obtained.

When gas alone was supplied to the burners, combustion could not be sustained, probably due to the gas velocity being higher than the velocity of flame propagation. In case of accidental stoppage of oil supply, the boiler setting would fill rapidly with an explosive mixture of gas, introducing a quite serious hazard.

Emergency Oil Burning System in Combination With Coal

Several years ago steam atomizing fuel oil burners were installed through the side walls of seven 5560-sq. ft. Stirling boiler furnaces at the Omaha steam electric station of the Nebraska Power Co. These were primarily to assist the ignition of the coal burned on chain grate stokers when the coal received was wet or coarse. These burners were installed for emergency service only and proved satisfactory for the purpose intended. They also provided the means of using an additional fuel source during periods of uncertainty of coal supply. The fuel pressure is kept constant at 60 lb. per sq. in. by a diaphragm governor on the pump. When not in use, the burners hang on the side walls of the boilers.

This arrangement does the work which it was designed to do but it is reported as being not very efficient on account of not having proper control of the air. The liquid fuel spray over the coal does not injure the stoker, sidewalls, or boiler arches but if the burner is not set properly, the coal gates become hot. It would seem that this scheme is practical for a standby plant.

Use of Gaseous Fuels

It seems to be the general opinion that natural gas is a more efficient fuel from the thermal standpoint than either coal or oil. This is not the case for natural gas of the ordinary composition where marsh gas and hydrogen amount to approximately 90 per cent, or more. The loss due to hydrogen will always be in the neighborhood of 11 per cent when flue gas temperatures are approximately 500 deg. F. In view of this loss, together with that of the flue gas which may be calculated and allowing 3 to 5 per cent loss for radiation and "unaccounted for", it does not seem possible to obtain even under test conditions some of the high boiler efficiencies reported.

It may be stated that where theoretically possible efficiencies are concerned, coal will give the highest value, oil the intermediate, and natural gas the lowest. This is based entirely on the assumption that all fuel can be burned with the same excess air giving approximately the same flue gas temperatures and that with perfect combustion, the only difference in the losses would be that due to the burning of the hydrogen. With the average coal, the hydrogen loss is in the neighborhood of 3.5 per cent, with mid-continental fuel oil, it is approximately 7 per cent and with the average natural gas it is in the neighborhood of 11 per cent. This partly explains why it is possible to obtain such high boiler test efficiencies as have been reported for powdered coal.

Properties of Crude Oils from California

THE BUREAU of Mines has completed a survey of the physical and chemical properties of crude oils of California. This work is part of a general investigation of typical crude oils in the United States. Typical samples of crudes from the various fields in California were collected over a rather wide interval of time, from 1919 to 1923. The samples are fairly representative, both of the settled production from the older wells and the flush production of new wells in the southern parts of the state.

It was found that the crudes of California, as was expected, differ decidedly in some properties. Gravities ranged from 6.8 deg. A.P.I. for a sample from the Casmalia field in Santa Barbara county to 51.6 deg. for a sample from the West Elk Hills field in Kern county. Most of the crudes, however, are rather heavy, 85 per cent of those tested had a gravity below 30 deg. A. P. I. (0.876 sp. gr.). Sulphur varied from 0.10 to as much as 4.13 per cent, the mean content for all the samples was 1.07 per cent. Carbon residues, by the Conrad determination, of residuums from the vacuum distillations also vary between wide limits, 8.3 per cent for a sample from Lost Hills to 35.9 per cent for one from Casmalia. Most of the samples tested 10.6 to 15.6 per cent, averaging 13.1 per cent carbon. About half of the crudes poured below 5 deg. F., but some ranged anywhere from 10 deg. F. up to an extreme of 75 deg. F.

Likewise, the gasoline content varied widely, 16 samples had no gasoline, 13 showed up to 10 per cent, 36 ranged between 10 and 25 per cent, 19 between 25 and 50 per cent, and 3 had more than 50 per cent gasoline. The gasoline fractions were heavier than for corresponding cuts from eastern or Mid-Continent fields. Very little kerosene was found in crudes from southern California, and none in the crudes from San Joaquin Valley and North Coast fields. Refiners, however, produce small amounts of kerosene from these crudes, by cutting into the "gasoline and naphtha" fraction.

In general, the crudes from the San Joaquin Valley and the northern coast fields are mostly naphthenic in character, while most of the samples from the southern coast fields are "intermediate" between naphthenic and parrafin base and less viscous than the former.

This survey is published as Serial 2595, by the Bureau of Mines, and contains detailed tables of the results of the distillation tests of California crudes.

Adapting Evaporators to Heat Balance---II

CONSIDERATION OF CYCLES IN WHICH EXTRACTION STEAM IS USED FOR FEED WATER HEATING. BY ERNEST H. CHAPIN*

STAGE heating of condensate, as it returns from the main condenser to the boilers, is a fairly recent development in its present practical form, and has been adopted by the majority of large power stations built in the last year or so. Figure 8 indicates a simple cycle, with conventionalized figures.

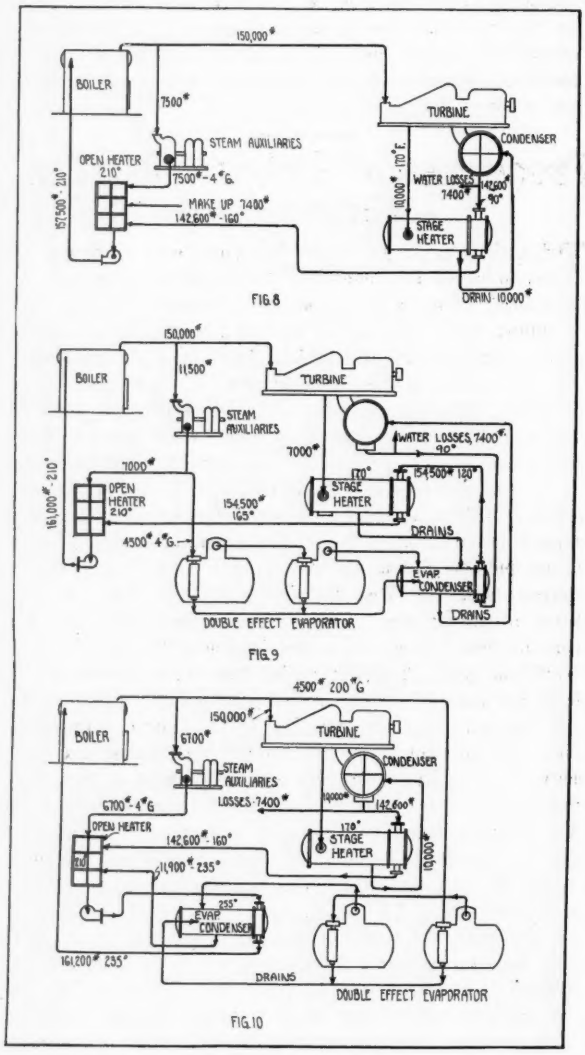


FIG. 8. CYCLE C USES EXTRACTED STEAM FOR STAGE HEATING OF THE CONDENSATE

FIG. 9. EXHAUST STEAM FOR EVAPORATING AND BLED STEAM FOR STAGE HEATING ARE CHARACTERISTICS OF CYCLE C-1

FIG. 10. LIVE STEAM IS USED IN CYCLE C-2 FOR THE EVAPORATORS

Single stage heating may or may not be desirable for most stations, but in any event, it is a possibility for stations having a low load factor or having other characteristics which would prohibit the installation of the equipment necessary for multiple stage heating. With only one extraction heater, it is assumed that it would be somewhere between the lowest practical bleeder stage and the moderately high bleeder point, thus balancing the maximum power production from a pound of steam, brought about by bleeding from the lowest possible point against the total amount of steam extracted, or the maximum rise it is possible to give the condensate in one stage.

Two possible arrangements of an evaporator unit under such station heat cycle conditions follow:

C-1. EXHAUST STEAM EVAPORATORS WITH SINGLE STAGE EXTRACTION

Figure 9 shows cycle C-1, where a double effect evaporator has been installed, using exhaust steam at approximately 4 lb. gage pressure in the coils of the first effect, and discharging its vapors into a separate evaporator condenser. Main condensate, at 90 deg. F. is used for cooling the evaporator condenser, the extraction heater taking it at the discharge temperature of 120 deg. F. and heating it to 165 deg. F.

This cycle is based on the assumption of the existence of the steam driven auxiliaries, producing the amount of exhaust steam as shown, namely, 11,500 lb. per hr., which is more than that indicated in the cycle C, without evaporators.

This scheme has the general effect of decreasing the amount of steam bled from the main turbine. The amount of exhaust steam going to the station heater will have to be maintained the same as in the scheme without evaporators, as indicated in cycle C, Fig. 8. Thus with the evaporators installed in the fashion indicated, additional exhaust steam will have to be provided to the amount used by the evaporator. This amount of extra steam for the evaporators is diminished by increasing the number of evaporator effects, or by maintaining a lower water loss figure. The diagram, Fig. 9, indicates a large amount of make-up when compared with actual figures in some well operated power stations. If it is placed at a higher level, the extraction heater rise can be kept the same as in cycle C, with the insertion of the evaporator into the cycle. With such an arrangement, the same amount of steam, namely 10,000 lb., could be bled, as indicated in Fig. 8, with evaporators in operation. This alteration would place the steam consumption of the auxiliaries back to the same figure of 7500 lb., as in cycle C, Fig. 8, 4500 of which would go to the evaporator, the remainder to the station heater.

Usually the apparent loss in economy of locating the bleeding point at a higher stage is more than accounted for in the simplicity and flexibility of the scheme, the minimizing of the size of the evaporator, and particularly justified with a load factor somewhat less than normal, or low amount of make-up water required.

C-2. LIVE STEAM EVAPORATORS WITH SINGLE STAGE EXTRACTION

The evaporator unit, shown in Fig. 10, is added, so to speak, to the existing heat cycle. The various intermediate temperatures in the stage extraction heater and the station heater remain the same. Boiler steam is led

*Wheeler Condenser & Engineering Co.

to the coils of the first effect evaporator, and the discharge from the boiler feed pump forces the hot water at 210 deg. F. through the evaporator condenser, where it is heated to 235 deg. F. under the conditions shown in the cycle C-2 and enters the boiler at that temperature.

Where the additional withdrawal of 4500 lb. of steam direct from the boiler is not desirable, this scheme would not be practicable. In most cases, the cycle could best be arranged so that all steam would pass through the main turbine and be taken off at some moderately low stage, thus obtaining some useful power before passing it to the evaporator.

D. Extraction Heating in Two Stages

Figure 11 shows another step, where a second extraction heater has been added to the single extraction cycle. Some steam driven auxiliaries are assumed, although in many cases all might be entirely motor driven.

The main condensate passes through the first extraction heater, where it is heated to 160 deg. F. and then through the second heater, where a temperature of 190 deg. F. is produced. The exhaust steam from the steam auxiliaries then raises the temperature to 210 deg. F. in the station heater. If a generator air cooler, steam jet air pump, or oil cooler is installed, the condensate would pass through these before going to the first extraction heater, in practically all cases.

Drains from the two extraction heaters are flashed in series, from one heater to the other, and then back to the main condenser, in the given cycle, although the alteration of this scheme would not materially affect the heat cycle.

D-1. Step-Down Evaporator Arrangement with Two Stage Extraction

In applying evaporators to the two-stage extraction cycle, there are several schemes which can be favorably considered, the amount of make-up, load factor of station, and other elements being the deciding factors.

Figure 12 shows the double effect evaporator taking steam from the higher extraction stage, and discharging its vapors into the lower extraction heater, thus stepping down part of the steam bled from the higher point of extraction.

Theoretically, it incurs some loss in possible power, which would be obtained by letting this steam pass on through the turbine, and extracting it at the lower stage; however, if the make-up requirements are moderately low, say 3 per cent, in actual operation, this theoretical power loss would be in many cases more than offset by the simplicity and flexibility of the arrangement.

In the given arrangement, with the make-up of 7400 lb. per hr., or 4.8 per cent, the steam extracted from the higher stage going to the extraction heater would be slightly increased, from 4300 lb. to 4500 lb. per hour, due to the increased amount of combined condensate under the C-1 arrangement. The additional amount of 4500 lb. extracted for the evaporator then takes the place of the same amount of steam from the lower stage, cutting the total amount bled from the lower stage from 10,000 lb. to 6000 lb.

With the evaporator shut down, the proportions of bled steam are as in Fig. 11, cycle D, or exactly the same as if no evaporators were installed.

Where the steam driven auxiliaries are eliminated, the two stages, or the higher stage, can be placed at a higher point in the pressure range of the turbine, and more economical arrangements made for any given condition. The temperature of the condensate leaving the higher stage heater is constant, whether the evaporators are in operation or not—an extremely desirable feature to consider, as the evaporators will not likely be in operation all the time.

D-2. Modified Step-Down Evaporator Arrangement with Two-Stage Extraction

Figure 13 shows a modified arrangement of cycle D-1, in which the vapors from the evaporator are condensed in

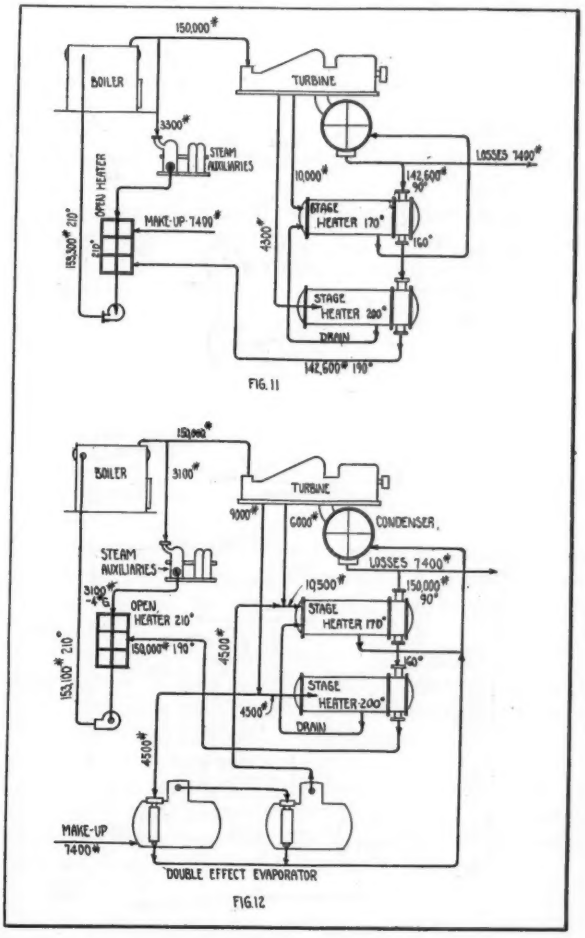


FIG. 11. EXTRACTION HEATING IN TWO STAGES IS THE FEATURE OF CYCLE D

FIG. 12. CYCLE D-1 EMPLOYS DOUBLE EFFECT EVAPORATOR, STEPPING STEAM DOWN FROM FIRST TO SECOND STAGE OF EXTRACTION

a separate evaporator condenser and the main condensate is used for cooling water before it goes to the first extraction heater.

This gives the same theoretical economy as cycle D-1 but provides a greater temperature head over the evaporator, thus making possible a smaller size evaporator for the same amount of distilled make-up water. It also provides a certain amount of segregation of elements, in that the evaporator can run with either or both of the extraction heaters cut out. If the higher stage heater is raised

to a higher extraction pressure, say where the saturated temperature of the bled steam is 230 deg. F., with the steam driven auxiliaries eliminated, and the station heater discarded, then the theoretical heat loss would be minimized. Such an arrangement, to give a final temperature of 210 deg. F., would result in 12,100 lb. of steam being condensed in the higher stage heater, and the same amount as shown, or 6000 lb., being condensed in the lower stage heater, while the evaporator condenser would condense 4500 lb. of steam, the heat of which would have come from the higher stage extraction opening in the turbine. This total amount, or 22,600 lb., might be modified by considerations of turbine operation but the point illustrated could be applied under such modified requirements, just as well.

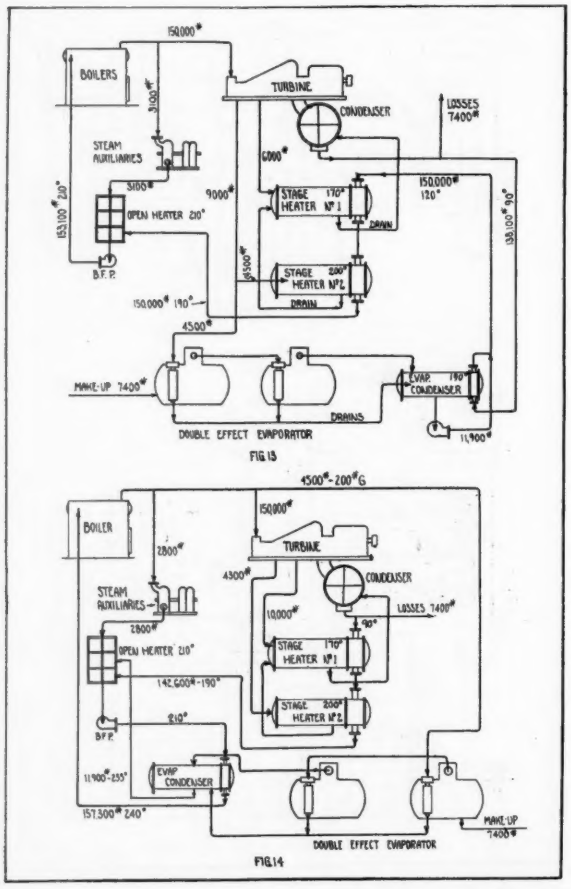


FIG. 13. IN CYCLE D-2 THE ADDITION OF AN EVAPORATOR CONDENSER REDUCES THE SIZE OF THE EVAPORATOR

FIG. 14. LIVE STEAM FOR EVAPORATORS AND TWO STAGE EXTRACTION ARE FEATURES OF CYCLE D-3

Justification of the separate evaporator condenser lies in the simplicity, flexibility and independence of the stage heater system, from the evaporator system, one being able to operate with the other shut down, as required, without altering the final temperature of the water going to the boilers.

D-3. Live Steam Evaporators with Two Stage Extraction

Application of a live steam operated evaporator unit is illustrated in Fig. 14, cycle D-3. Referring to cycle C-2, Fig. 10, the two are essentially the same, the evaporator unit being "added" to the existing cycle, and the temperature going to the boilers being raised from 210 deg. F. to 240 deg. F., by the evaporator condenser.

Many consider it better economy, however, to avoid such an arrangement, with two stage extraction heaters, and put all steam through the turbine, getting as much work from the steam as possible and bleeding off from a suitable point for evaporator operation, as well as for the extraction heater system.

D-4. Bled Steam Evaporator with Two Stage Extraction Heating

What is really a mid-way arrangement between the live steam operated evaporator scheme, illustrated in Fig.

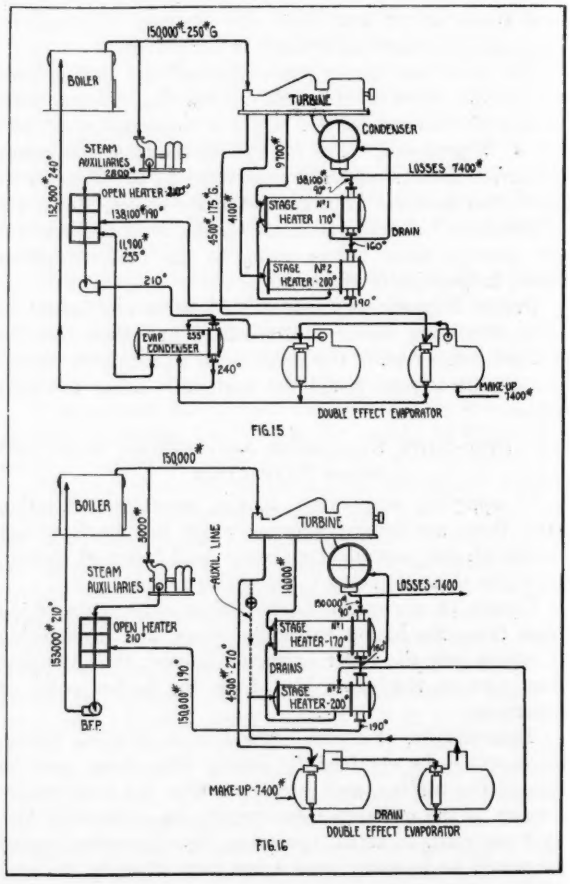


FIG. 15. CYCLE D-4 USES BLED STEAM FOR EVAPORATOR AND TWO STAGE EXTRACTION HEATING

FIG. 16. TWO STAGE EXTRACTION WITH SECOND STAGE HEATER CONDENSING EVAPORATOR VAPOR CHARACTERIZES CYCLE D-5

14, and the extraction heater steam operation, Fig. 12, is the use of a separate bleeder connection for the evaporator steam supply. This is illustrated in Fig. 15, cycle D-4.

Steam is extracted from the turbine at a rather high pressure, for evaporator operation, and, of course, comparatively little work is obtained from this steam, in its short travel through the turbine, as compared with the steam for evaporator operation taken from the higher of the two extraction heater supply lines, in D-1.

It provides an evaporator unit operating at a heat

level above the two extraction heaters and the vapors are condensed by a separate evaporator condenser, using the discharge from the boiler feed pump for circulating water.

If the steam auxiliaries are shut down, or motor operation substituted, the evaporator vapors can be condensed in the station heater, thus eliminating the evaporator condenser. Such modification would tend to hamper the auxiliary operation, limit the flexibility of the temperature control at less than full load conditions and would not be particularly desirable from many standpoints.

D-5. Modified Step-Down Arrangement with Two Stage Extraction

Figure 16 illustrates an extremely flexible and simple arrangement, made possible by placing the higher of the two extraction stages high enough to provide the evaporator with enough temperature head so that the evaporator vapors can be condensed in the higher extraction heater.

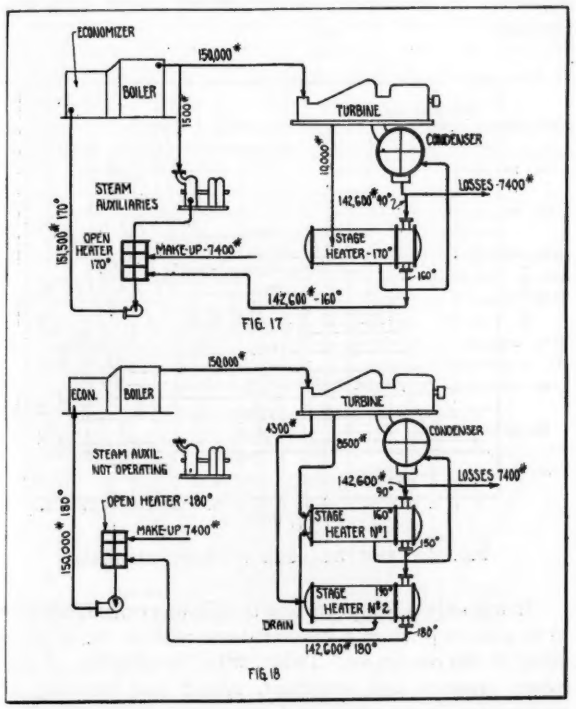


FIG. 17. ADDING AN ECONOMIZER TO THE PLANT CHANGES CYCLE C TO CYCLE E

FIG. 18. CYCLE F HAS AN ECONOMIZER AND TWO STAGE HEATERS IN THE CIRCUIT

Under the given conditions of operation, when the evaporator is in operation, the higher extraction heater really acts as the evaporator condenser, receiving no steam from any extraction stage direct. This arrangement allows of the maximum quantity of steam extracted from the turbine at the lowest stage, thus all the steam possible can be taken from the turbine where it is most desirable to do so—namely, at the lower stages. The only real difference in this scheme, is that the "step-down" is taken from between the two extraction heaters and placed outside of the operation of the lower extraction heater.

With the evaporator shut down, the steam formerly going to the evaporator and there giving up its heat to the higher stage heater goes direct to the heater and the same outgoing water temperature is maintained. As the steam is considerably higher in pressure than necessary to give the same temperature, a regulating valve may be installed in this bypass line. The lower extraction heater is entirely unaffected by this arrangement.

E. Evaporators with Economizers and Single Stage Extraction

When economizers are installed in the power station, there are certain requirements in the station cycle that must be met to take full advantage of this piece of equipment. In general, this modification suggests a constant, lower temperature of feed water, to obtain the maximum economy, whereas, with boilers alone, this consideration might not have any particular effect on overall station economy, if the heat in the steam used to obtain this additional temperature could have been handled in some other way.

Referring to Fig. 17, the assumed cycle, E, has been arranged to show a temperature of 170 deg. F. entering the economizer. Using the evaporator arrangement already described under cycle C, Fig. 8, it can be seen that cycle C-2, Fig. 10, illustrating the live steam operated evaporator unit, should not be used if the low economizer temperature is desired.

On the other hand, cycle C-1, Fig. 9, showing the exhaust steam operated evaporators, would fit in with an economizer installation without altering the maximum economy of the economizer in this respect.

F. Evaporators with Economizers and Two Stage Extraction

Figure 18 shows cycle F, without evaporators, and indicates economizers installed with two stages of extraction heating. This cycle is similar to that shown in Fig. 11, cycle D, but with the addition of economizers and the lowering of the economizer feed temperature to 180 deg. F.

The cycle D-1, Fig. 12, would apply to cycle F, without decrease in the economizer efficiency, and in the same way cycle D-2, showing the evaporators with a separate condenser, Fig. 13, could be used.

Live steam operation of the evaporator would incur a rise in the economizer feed temperature, therefore the evaporator cycle illustrated in Fig. 14, D-3, would not be desirable unless special conditions entered, not indicated in the diagram, to allow of its consideration.

Pulverized Fuel Data

COMPARING first cost of pulverizing mills with cost of power to operate, E. Kilburn Scott in Combustion shows that for a mill costing $4800 and requiring 85 hp. as against one costing $9600 and requiring 50 hp., the difference in cost will be saved in 4 yr. This is on the assumption of a cost of about 4 cents a kw.-hr., capacity being provided to crush 3 T. an hour to pass 85 per cent through a 200-mesh screen.

To burn a pound of combustible will require about 180 cu. ft. of air at atmospheric pressure and temperature of 500 deg. F. at final temperature of 3000 deg., the volume will be six times the original, and velocity of gases through the combustion chamber has been found to be 5 ft. per sec. Best results are obtained when burning 1 to 1.5 lb. of coal per cubic foot of combustion space per hour.

Tendencies in Steam Turbine Plant

HIGH PRESSURES AND TEMPERATURES, STAGE EXTRACTION AND REHEATING
DISCUSSED BEFORE THE NEW YORK SECTION OF A. S. M. E. BY ESKIL BERG

IMPORTANCE of the adoption of high steam pressure, high steam temperature, reheating of steam and steam extraction is probably best illustrated by the fact that today in this country there are being built six large central power stations in which all these features have been adopted. Chicago, for instance, is today building a station which will consist of two 50,000-kw. turbines and one 60,000-kw. turbine, which will be operated at 600 lb. boiler pressure, 700 deg. F. steam temperature, steam reheated to 700 deg. F. at approximately 100 lb. pressure and

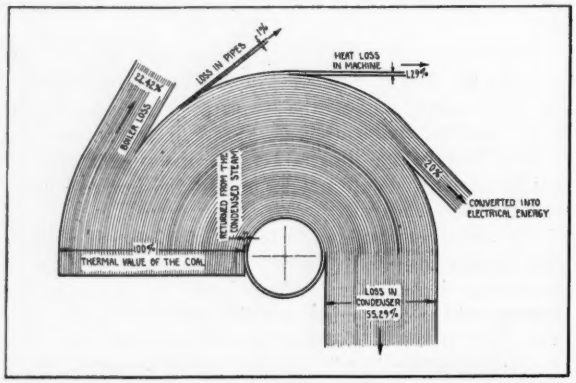


FIG. 1. ENERGY DIAGRAM FOR A STATION OPERATING WITH 250 LB. PRESSURE, 200 DEG. F. SUPERHEAT AND A GOOD VACUUM

steam extracted from the turbine to heat the feed water to approximately 300 deg. F.

The Edison Illuminating Co. of Boston, in its new Weymouth Station, is installing one large boiler with 1200 lb. pressure, 725 deg. F. steam and a 3500-kw. turbine which will take steam at 1200 lb. pressure with a steam temperature of 725 deg. F., exhausting into the main steam line of 350 lb. pressure. This high pressure boiler for the Weymouth Station is designed to handle 130,000 lb. of steam per hour.

IMPROVEMENT IN STEAM TURBINE

Steam turbines today have reached a point of development where their efficiency is within a few per cent of that theoretically obtainable so that further improvements cannot materially reduce the fuel consumption. We must, therefore, look towards the steam condition itself and that is the reason why central station managements all over the world today are looking toward improved steam conditions.

It can readily be seen that the more energy (B.t.u.) we can supply to each pound of steam when it enters the turbine, the less number of pounds will naturally be required to produce a unit of power. To supply more energy to a pound of steam means to raise its temperature. This can be done either by raising the steam pressure, adding superheat or doing both. Steam can also be extracted from the turbine at some lower pressure, then reheated and led back to the turbine.

Figure 1 represents graphically how the energy of a pound of coal is distributed in a first-class power station using 250 lb. pressure, 200 deg. F. superheat and under good vacuum conditions. This shows that 20 per cent of the energy in the coal is converted into electrical energy, which figure corresponds to 17,075 B.t.u. per kw.-hr. This is about the lowest figure at which power has been produced under the above steam conditions.

It will also be noted that the condenser loss is by far the largest loss, being 55.29 per cent of the heat value of the coal. With this picture in view, it will easily be understood that the better the steam consumption is per kilowatt-hour, the less steam goes to the condenser. Consequently the condenser loss is reduced in the same proportion.

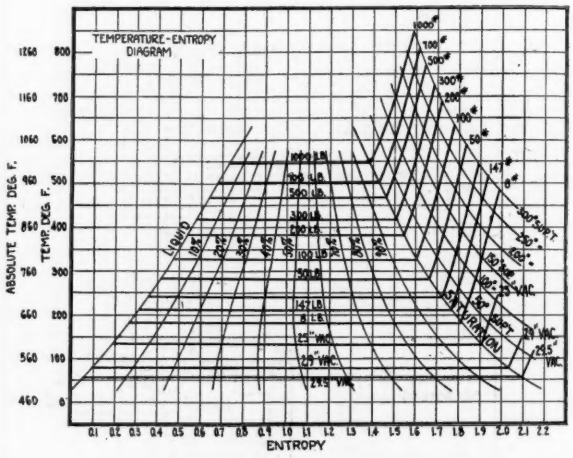


FIG. 2. TEMPERATURE-ENTROPY DIAGRAM

It was only a few years ago that it was considered good to be able to produce a kilowatt-hour with 14 lb. of steam going to the condenser. Today, with the adoption of high steam pressure and superheat, reheat and bleeding the turbine for heating the feed water, this figure has been more than cut in half, which means that the condenser loss is practically cut in half.

Total heat of steam gradually increases with the pressure until it reaches its maximum at 370 lb. absolute and remains constant up to 395 lb. absolute, after which the total heat decreases. At 1200 lb. pressure the total heat is only 1179.7, which is the same as at 62 lb. abs. By raising the steam pressure from 200 lb. to 1200 lb., the total heat will be reduced from 1198.5 B.t.u. to 1179.7, or 1.58 per cent, while the energy will be increased from 272,000 ft.-lb. to 337,000 ft-lb., or 24 per cent, which means a net gain of 25.5 per cent.

HIGH SUPERHEAT

Theoretical gain by the use of superheat is almost negligible. There is, however, a practical gain in its adoption which makes superheat necessary. It is clear by looking at the entropy diagram, Fig. 2, that the moisture in the exhaust increases as the initial pressure is increased. Moisture in a turbine affects its efficiency and is its greatest source of loss.

Losses in an average, well-designed turbine of the impulse type, when dry initial steam is used, are of the following magnitude:

Loss due to friction in nozzles and blades and windage loss of disks and blades	20%
Steam leakage loss	3%
Rejected energy (due to residual steam velocity)	3%
Bearings, packings, etc.	1%
Total loss	27%
Efficiency of turbine	73%

It will be seen that the first item is by far the largest one and the moisture in the steam in all the stages has greatly increased this loss. If, on the other hand, steam instead of being dry had entered the turbine with 200 deg. of superheat, it would be found that this loss would be reduced from 20 per cent to about 15 per cent and the turbine efficiency would be increased from 73 per cent to 78 per cent.

Figure 3 shows a cross section of a turbine having 10 stages and gives approximately the condition of the steam

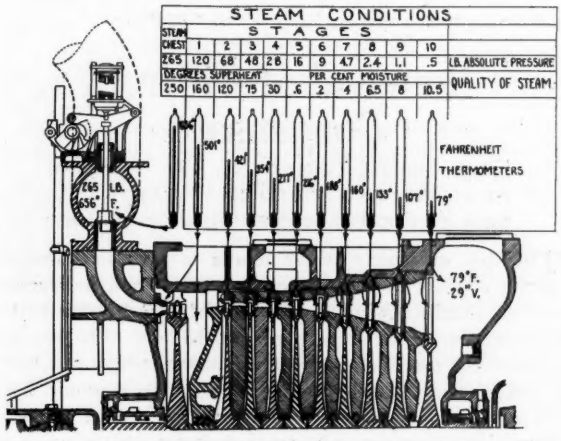

STEAM CONDITIONS
STAGES
STEAM CHEST 1 2 3 4 5 6 7 8 9 10
265 120 68 48 28 16 9 4.7 2.4 1.1 .5 LB. ABSOLUTE PRESSURE
DEGREES SUPERHEAT PER CENT MOISTURE
250 160 120 75 30 .6 2 4 6.5 8 10.5 QUALITY OF STEAM
FAHRENHEIT THERMOMETERS
265 LB. 656" F.
79°F. 29"V.

FIG. 3. STEAM TEMPERATURES IN A 10 STAGE TURBINE

in all the stages. This turbine has 80 per cent efficiency and is supplied with steam at 250 lb. gage pressure, 250 deg. F. superheat and is exhausted into a 29-in. vacuum.

Gain by High Steam Pressure and Superheat Combined

Figure 4 gives the ratio of available B.t.u. in steam to the total heat in steam, giving credit for the heat in the condensate which is returned at a temperature of 90 deg. F. Up to the present time the standard steam pressure for large power stations has been 250 lb. with superheat of about 200 deg. F. and 28.5 in. vacuum. From the curve this gives a ratio of 32.8 per cent. At the present time several large stations are being built in this country which have adopted 550 lb. and 725 deg. F. From the curve this gives a ratio of 36.9 per cent. With the same turbine and boiler efficiency this would mean a saving of 12.2 per cent. The ratio 36.9 would give a kilowatt-hour, assuming a turbine efficiency of 75 per cent and boiler efficiency of 80 per cent, with $0.369 \times 0.75 \times 0.8 = 0.222$. As one kilowatt-hour equals 3415 B.t.u., this corresponds to $3415 \div 0.222$ equals 15,350 B.t.u., to which has to be added

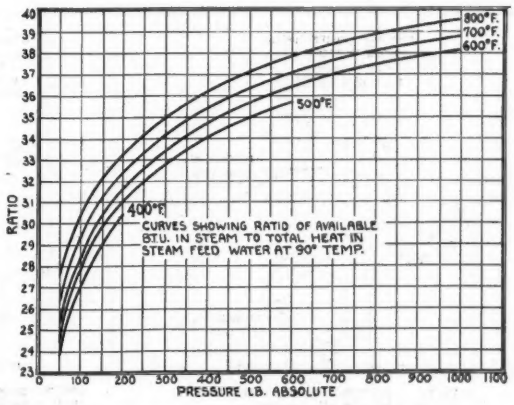


FIG. 4. CURVES SHOWING RATIO OF AVAILABLE B.T.U. TO TOTAL HEAT IN STEAM

about 5 per cent for station auxiliaries, making it 16,100 B.t.u.

Steam Extraction

Figure 5 shows approximately the theoretical gain by the use of 1, 2, 3, 5 and 20 heaters. While these curves are calculated for 500 lb. gage, 700 deg. F. and 29 in. vacuum, they can be used with comparatively small error for other pressures and temperatures. If the steam is initially dry, the gain would be larger than what is shown but only by a couple of per cent. The extraction of steam for heating feed water also shows an important gain, namely: the more steam we extract from the turbine before it reaches the condenser, the less steam naturally goes to the condenser, which means a corresponding reduction of heat loss in the condenser.

Reheating the Steam

From a glance at the entropy diagram given in Fig. 2 it will be seen that, when adopting a pressure of 500 lb. and above, there will be excessive moisture in the low pressure end of the turbine. Reheating is, therefore, more advisable under those steam conditions than when lower steam pressure is used, although at the lower pressure it is also advisable. With a low initial pressure (250 lb.) the reheating is done at about 50 lb. pressure. The volume of the steam at this pressure is rather large, requir-

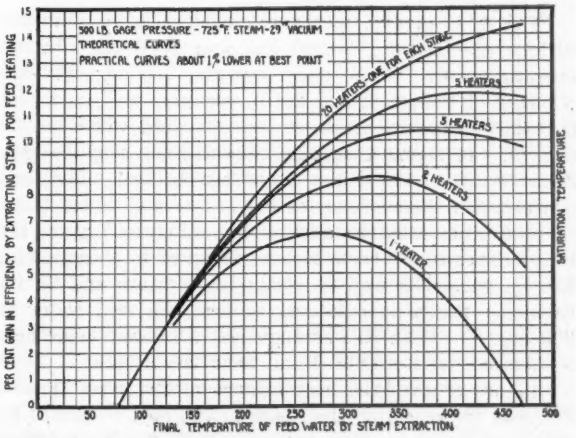

500 LB. GAGE PRESSURE - 725°F. STEAM - 29" VACUUM
THEORETICAL CURVES
PRACTICAL CURVES ABOUT 1% LOWER AT BEST POINT
20 HEATERS - ONE FOR EACH STAGE
5 HEATERS
3 HEATERS
2 HEATERS
1 HEATER
PER CENT GAIN IN EFFICIENCY BY EXTRACTING STEAM FOR FEED HEATING
SATURATION TEMPERATURE
FINAL TEMPERATURE OF FEED WATER BY STEAM EXTRACTION

FIG. 5. CURVES SHOWING GAIN IN EFFICIENCY DUE TO HEATING FEED WATER BY STEAM EXTRACTION

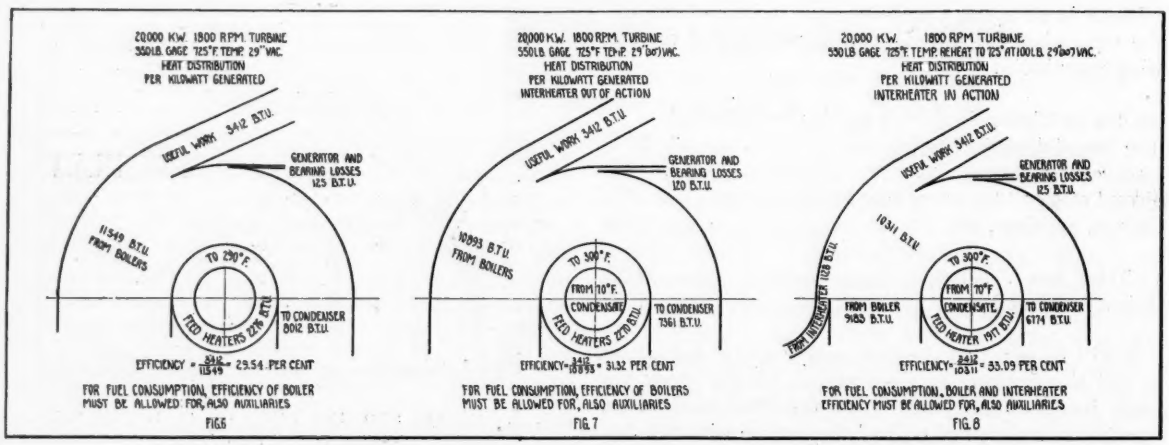

20000 KW 1800 RPM TURBINE
350 LB. GAGE 725°F. TEMP. 29" VAC.
HEAT DISTRIBUTION
PER KILOWATT GENERATED
USEFUL WORK 3412 B.T.U.
GENERATOR AND BEARING LOSSES 125 B.T.U.
11549 B.T.U. FROM BOILERS
TO 290°F.
FEED HEATERS 2276 B.T.U.
TO CONDENSER 8012 B.T.U.
EFFICIENCY = 3412/11549 = 29.54 PER CENT
FOR FUEL CONSUMPTION, EFFICIENCY OF BOILER MUST BE ALLOWED FOR, ALSO AUXILIARIES
FIG.6
20000 KW 1800 RPM TURBINE
550 LB. GAGE 725°F TEMP. 29" VAC.
HEAT DISTRIBUTION
PER KILOWATT GENERATED
INTERHEATER OUT OF ACTION
USEFUL WORK 3412 B.T.U.
GENERATOR AND BEARING LOSSES 120 B.T.U.
10893 B.T.U. FROM BOILERS
TO 300°F.
FROM 70°F.
CONDENSATE
FEED HEATERS 2220 B.T.U.
TO CONDENSER 7361 B.T.U.
EFFICIENCY = 3412/10893 = 31.32 PER CENT
FOR FUEL CONSUMPTION, EFFICIENCY OF BOILERS MUST BE ALLOWED FOR, ALSO AUXILIARIES
FIG. 7
20000 KW 1800 RPM TURBINE
550 LB GAGE 725°F. TEMP. REHEAT TO 725°AT 100 LB. 29" VAC.
HEAT DISTRIBUTION
PER KILOWATT GENERATED
INTERHEATER IN ACTION
USEFUL WORK 3412 B.T.U.
GENERATOR AND BEARING LOSSES 125 B.T.U.
10311 B.T.U.
FROM INTERHEATER 108 B.T.U.
TO 300°F.
FROM 70°F
CONDENSATE
FEED HEATER 1917 B.T.U.
FROM BOILER 9185 B.T.U.
TO CONDENSER 6774 B.T.U.
EFFICIENCY = 3412/10311 = 33.09 PER CENT
FOR FUEL CONSUMPTION, BOILER AND INTERHEATER EFFICIENCY MUST BE ALLOWED FOR, ALSO AUXILIARIES
FIG. 8

FIG. 6. HEAT BALANCE DIAGRAM OF A TURBINE WITHOUT REHEAT BUT WITH STEAM EXTRACTION
FIG. 7. HEAT BALANCE FOR TURBINE OPERATED WITH 550 LB. PRESSURE AND WITH STEAM EXTRACTED
FIG. 8. HEAT BALANCE FOR TURBINE ARRANGED FOR REHEATED STEAM AND STEAM EXTRACTION

ing a large size reheater in order not to have too much drop in steam pressure through the reheater. The most economical pressure at which to do the reheating varies but, as a rule, it will be found to be around one-fifth of the initial boiler pressure.

Theoretically, as with initial superheat, the gain is small, being about 3 per cent if the steam is extracted at one-fifth the initial pressure and reheated to original temperature. The decrease in water rate is, however, about 4 per cent, due to reduction of friction losses in the turbine. There is, of course, a slight pressure loss due to the piping and the reheater itself, so that the net gain will be about 6 per cent in efficiency.

Use of an Economizer

Steam extraction from the turbine for heating the feed water is so efficient that the use of economizers would seem unnecessary; however, the flue gas temperature must be kept low in order to keep the efficiency of the boiler plant high. Thus, if economizers are omitted, the waste heat from the gases must be used to preheat the air going to the boilers. Grate manufacturers at the present time prefer to limit the temperature of the air to 300 deg. F. or below. With oil or powdered coal, high air temperature has proved rather beneficial.

Figure 6 gives typical heat balance of a tentative turbine designed for 20,000 kw. and 1800 r.p.m. when operating with 350 lb. gage pressure, 725 deg. F. temperature of the steam and 29 in. vacuum, with no reheat but with steam extraction to heat the feed water to 290 deg. F. It shows that one kilowatt-hour may be produced with 11,549 B.t.u. from the boilers. For fuel consumption the efficiency of the boilers and power taken by auxiliaries must be allowed for. Figure 7 gives the heat balance of the same turbine designed to operate with 550 lb. gage, 725 deg. F. steam temperature and 29 in. vacuum. Steam is extracted to heat the feed water to 300 deg. F. With this arrangement a kilowatt-hour may be obtained with 10,893 B.t.u. from the boilers.

Figure 8 gives the heat balance of the same turbine designed for reheating the steam to 725 deg. F. at 100 lb. gage and gives one kilowatt-hour with 10,311 B.t.u. This figure, assuming 80 per cent boiler efficiency and 6 per cent for auxiliaries, would mean 13,700 B.t.u. from the fuel. With oil or powdered coal where full advantage can be taken of air preheating the boiler efficiency may reach as high as 90 per cent, in which case the fuel consumption would compare favorably with Diesel engines.

Removal of Oil from Condensate

Tests Indicate Successful Use of Steam Separators and Filters in Preparing Condensate for Boiler Feed. By A. E. Walden

THERE are many power plants in operation that do not attempt to utilize the condensate from the engines and auxiliaries, owing to the fear of damage due to the introduction of lubricating oil into boilers. The loss due to scale and corrosion is greater, however, where raw water is heated and supplied to the boilers than it would be if the oil was partially or wholly removed from the condensate, only enough raw water being added to make up the loss.

On page 952 of the September 15, 1923, issue of Power Plant Engineering, the writer discussed a method of calculation of the quantities of cylinder oil going to a given cylinder and the formula and constants that had proved satisfactory in practice.

It is usual in practice to base the removal of cylinder oil from the feed water in grains of oil per gallon, for separation or for filtration. A suitable cylinder oil for steam that is wet is an oil compounded with 6 to 7 per cent of acidless tallow and for dry or superheated steam a straight mineral cylinder oil will be satisfactory, but if the latter is used with wet steam, twice the quantity will be required. The tallow has the effect of causing the oil to adhere to the smooth metal surfaces.

Methods of removing oil from the condensate were studied by the writer, namely, separation by eliminators or separators and by filtration through coke or terry cloth, some of the results from actual operation are here given.

Separators placed in the exhaust line for the removal of oil should be at least two sizes larger than the exhaust pipe to reduce the velocity of the steam as it impinges on the baffles, the idea being that the atoms of oil do not readily lose their velocity but strike the baffles, are de-

posited on them, washed to the bottom of the separator and trapped to the sewer. This results in considerable loss of heat and condensate which in some cases will exceed 15 per cent of the total steam supplied to the engines.

Separators are usually guaranteed to reduce the quantity of oil in the condensate to ½ grain or less per gallon when the exhaust steam does not contain over 10 grains per gallon. This applies to filters also.

Coke filters usually consist of a container for the coke inside of a feed water heater and receives not only the condensate from the engines but the auxiliaries as well. Under these conditions it is necessary to watch the quantity of oil carefully.

Coke used is usually ordinary foundry coke broken up into units the size of an egg, with the dust washed out. Tests on coke gave results as follows:

Percentage by weight of water absorbed by dry coke..26.4
Percentage by weight of oil absorbed by dry coke.....88.8
Percentage by weight of oil absorbed by wet coke.....34.7

Actual absorption of oil by coke in filter by weight was 24.8 per cent.

Assuming one quart or 2 lb. or 14,000 gr. of cylinder oil used per day and 100 lb. of coke in the filter, the coke will absorb 24.8 lb. or 173,600 gr. of oil from the feed water and coke will have to be replaced in (173,600 ÷ 14,000) 12 days.

If the make-up water is clean, it is possible for the coke to absorb 34.7 lb., nearly, of cylinder oil in the same time, allowance being made for the variations in the porosity of the coke.

Terry Cloth Filters

There are a number of filters on the market using terry cloth as a filtering medium, and the results obtained from the use of such filters depend on the water, the velocity of flow through the filter, as well as the carefulness with which the data given the manufacturers as to the number of pounds of condensed steam and the quantity of oil supplied to the engines and auxiliaries was obtained.

Oil used in making the test of both coke and terry cloth was 600 W, fire test 600 deg. F., viscosity at 212 deg. F. was 183.

Average weight of terry cloth per square foot, dry	1301.15 grains
Average weight of water absorbed by dry cloth, per square foot	2942.63 grains
Average weight of oil absorbed by dry cloth, per square foot	3975.34 grains
Average weight of oil absorbed by wet cloth, per square foot	3466.04 grains
Average weight of oil absorbed by wet cloth, per square inch	24. grains

The data and following tabulation was obtained from operating results in a number of plants. The variation in hours run between cleanings are undoubtedly due to operating conditions, including quality of raw water, assuming the filters to be of sufficient size. A plant having a filter with 6-in. connections and 9499 sq. in. of filtering area in the cloth absorbed 38 lb. of oil in 24 hr., or 28 gr. per sq. in. of area, the ratio of inlet pipe area to filter cloth area was 1 to 365 sq. in.

FILTER SIZES AND AREAS

Standard pipe Size in.	Area sq. in.	Feed Water per Hour Cu. ft.	Gal.	Filter Area Sq. in.	Best Results
2	3.35	278	2085	1064	1270
2½	4.78	397	2977	1569	1820
3	7.38	610	4575	2422	2800
4	12.73	1070	8025	4178	4850
5	19.98	1650	12375	6564	7600
6	28.88	2400	16000	9499	10975
8	50.02	4160	31200	16500	19000

For best results the area was determined from hours run and quantity of oil absorbed by a given area considering the velocity through the filtering medium. The hours run between cleanings varied from eight to seven days, with best results obtained from 24 to 72 hr. The pressure drop through filters varied from 10 to 20 lb. before cleaning.

Consideration of the above data indicates that there should be at least 330 sq. in. of effective filtering area for each square inch of area in the inlet connection to filter, with a velocity of flow through cloth of 0.01 ft. and through connection not exceeding 3½ ft. per second, preferably 3 ft. for best results and an effective area in cloth of 380 sq. in. to each square inch in the feed water inlet connection. Twin filters are preferable and should be provided with means for reversing the flow, washing, blowing down and with pressure gages on inlet and outlet to determine cleaning periods accurately.

In purchasing such filters it is always best to have a chemist determine the maximum quantity of oil in the condensate or feed water, checking this against an accurate determination of the cylinder oil supplied to the engines and auxiliaries daily.

This data with the total number of pounds of feed water supplied per day, its maximum and minimum temperature given to the manufacturers, requesting a statement as to proper size for best results with maximum runs between cleanings, with minimum pressure drop through filter, will assure successful feed water treatment in so far as oil removal is concerned.

Temperature of feed water going to the filter appears to have some effect on absorption of oil as indicated from operating results although this is not conclusive.

In some cases more oil seems to be absorbed at temperatures above 100 deg. and below 200 deg. F. than at temperatures over 200 deg. F. The oil being thinner, this will have the effect of shortening the length of time between cleanings.

Installation of such a filter and the re-use of the condensate will surely result in a saving in both fuel and boiler repairs as well as less oil in the engines and erosion of turbine blades due to clean boilers; even if a little oil goes into them, it will be a benefit tending as it does to prevent corrosion and there is no reason to fear its effect in such small quantities.

All kinds of brass may be soldered with Bath metal solder (79 copper, 21 zinc) or soft spelter, using borax as a flux. A good plan is to spread on a little paste of borax and water and lay a bit of tinfoil on this, then heating until the tin melts and runs and thus coats the surface. Work previously tinned in this way can be joined neatly and easily.

Earning Value of Power Plant Instruments

Use of Power Plant Instruments Results in Minimum Saving of 2 Per Cent and Probable Average of 10 to 15 Per Cent. By C. D. Zimmerman

SIX YEARS ago the prevailing opinion was that power plant instruments were a poor investment and in a number of installations the capital expended on power plant instruments was a complete loss. This was partly due to faulty meter construction which did not make them suitable for the severe service encountered in power plants and partly due to the fact that proper measures were not taken to keep the meters in operating condition or to apply the data furnished by the meters.

Today the use of instruments is almost universal in power plants. With this increased use a few new and valuable types of instruments have been developed and their adaptability to power plant use greatly improved.

Financial Gain

The reason for this increased use of meters is shown by the financial gain resulting from their use. With improved methods of using the data furnished by meters it is estimated that their use saves a minimum of 2 per cent of the coal. In the average plant a coal saving of 2 per cent pays in one year the first cost and maintenance of a complete meter installation. The cases in which the use of power plant instruments have saved a third of the coal are numerous and a probable average saving is 10 to 15 per cent.

Many plants without meter equipment report, "Very good operation. Orsat readings show a high CO_2, and the ash looks very good." The performance may be good but is generally not as good as it appears. It is a simple matter for a fireman to show a high CO_2 while an Orsat is being used and as these readings in plants of this kind are usually not taken more than once or twice a month they mean little. Investigation generally shows that the uptake damper is never used. As a consequence the daily average excess air is poor, the banking loss high, and the system of pressure regulation poor.

Effect of Plant Size and Boiler Size on Financial Gain

As the saving due to the use of power plant instruments depends mainly on the size of the boilers and the size of the total plant, the following is developed to give an indication of the extent to which meters should be installed in small power plants. The minimum saving naturally changes with the type of boiler and stoker installation, but a saving of 2 per cent is estimated as the minimum saving for any installation due to the proper use of meters over the best obtainable operation without meters.

For $650 a boiler can be equipped with meters showing the essential data (excess air, steam flow, flue gas temperature, and draft over fire). The maintenance or checking of these meters requires the services of a man skilled in this work for 2 to 4 hr. per boiler per month. In Table I the fixed charges are taken at about 20 per cent and the cost of maintenance and checking at $100.00 per boiler per year, which will pay the expense of having a man from the motor manufacturers for installations not large enough to merit the services of one man for this work. The boiler efficiency is assumed at 70 per cent, the average rating 120 per cent and the coal 12,000 B.t.u. per lb. as fired. No allowance is made for the decrease in efficiency for less than 24 hr. per day operation, which would naturally result, due to the banking for the remaining hours.

TABLE I. SAVINGS DUE TO BOILER ROOM INSTRUMENTS

Boiler Hp.	Hr. per Day: Tons Coal per Yr. 24	18	12	Saving, 2% $4 Coal 24	18	12	Meter Charges	Net Saving per Boiler per Yr. 24	18	12
200	4190	3142	2095	$335	$251	$168	$250	$ 85	$ 1	..
300	6284	4713	3142	503	377	251	250	253	127	$1
400	8379	6284	4190	670	503	335	250	420	253	85

Advantages of having a man or department in each plant to maintain the meters in accurate condition, calculate the results of operation and do miscellaneous test and planning work are discussed below. In plants having less than 20 boilers, less than half of one man's time should be taken for meter maintenance. Table II is based upon the savings shown in Table I and indicates the size of the plant which merits the employment of one man at a salary of $2000 per year for the duties just mentioned.

TABLE II. NUMBER OF BOILERS REQUIRED TO SAVE $2000 PER YEAR DUE TO INSTRUMENTS

Boiler Hp.	Hours per Day— 24	18	12
200	23	..	..
300	8	16	..
400	5	8	23

Application

Almost all power plants have a planning department (often called test, efficiency, or results department) as part of the organization. The organization and methods outlined below are not thought to be the only successful ones, but are considered to be the most valuable for the average plant. The work of the planning department should be carried out in all power plants. As outlined above, in small plants having less than eight boilers, the meter maintenance work can be done by a service man from the meter factory, in larger plants the meter maintenance and most of the duties of the planning department can be carried out by one man, and in the largest plants, 10 to 15 men are often used for this work.

The duty of the planning department is mainly to plan improvements in plant economy. In order to carry on this work the detailed results of power plant performance must be known periodically. As the data from which these results are calculated is furnished by meters, this is their most important use. Little and, at best, doubtful progress can be made unless the effect of changes can be seen in the records of actual performance. The detailed performance of the boiler room and turbine or engine room of all power plants should be known weekly.

Types of meters which rank second in importance are those which serve as a direct guide to the fireman in showing him continuously the output of the boiler and an indi-

cation of the condition of the fire as shown by a record of the CO_2, relative excess air, or CO_2 and combustible gases. With the majority of the present furnaces there is a certain value of excess air for which the total stoker losses are at a minimum. If less air is used, the saving in stack loss is overbalanced by the increase in the loss due to incomplete combustion and carbon in the ash, and if more air is used the increase in stack loss offsets the decreases in the loss due to incomplete combustion and carbon in the ash.

With boilers set only a few feet above the grate, variations from the proper excess air result in larger losses than occur with boilers set higher above the grate as in the latter case there is practically no loss due to incomplete combustion and the proper amount of excess air to use depends on the amount of ash in the coal and the burning quality of the coal.

As outlined above, a meter serving as a guide to the fireman is as valuable for installations of the latter type as for the type mentioned first. The great value of meters of this type for pulverized coal firing is shown by the facts that the loss due to carbon in the ash is practically nothing and that the largest losses and the only losses over which the fireman has control are the losses due to using too much or too little air.

One type of this kind of meter also serves as a guide and check on the banking operation.

Preventable loss due to stoker operation without meters varies from 2 per cent up, depending on the installation and the character of the operation.

Material gain is made by the application of data shown by meters, usually recording, from which indications of the proper or improper functioning of the important apparatus of the power plant can be derived. The most important and most commonly used of this type are temperature recorders for individual boilers showing the gas temperature at the boiler uptake and economizer outlet, superheated steam temperature, and feed water temperature. The same principle is often applied to other parts of the plant by the use of temperature recorders on the auxiliary exhaust steam, the condenser water and the turbine steam.

One method of application which insures that the actual performance is continuously compared with the performance of the apparatus in perfect repair is to give to the proper department head a weekly report showing the relative cleanliness or character of operation of boilers, superheaters, economizers, condensers, etc. For the boiler units, which are usually the most important, it is well known how the flue gas temperatures and degree of superheat change with rating and degree of excess air and that the relative cleanliness of the different heating surfaces is shown by the extent to which the temperatures depart from what they should be for the given condition.

Boilers without meters can be kept in a fair condition by the use of a routine inspection and cleaning system but faults in baffles sometimes develop which are not seen by inspection and are only found when temperature recorders show the fault must exist. Workmen are also not infallible and as boilers are unpleasant places in which to work or even rest the work is often slighted unless checked by a temperature recorder. The same troubles which cause excess flue gas temperatures almost invariably cause a decrease in the superheat. Faulty baffles or cleaning systems generally result in an increase of 100 deg. F. in the flue gas temperature. A decrease of 30 deg F. in the average flue gas temperature results in about 1 per cent fuel saving and an increase of 10 deg. F. in the superheat results in a fuel saving of about 0.6 per cent.

The remaining use to which meters are put in a power plant is research work which is naturally carried on almost entirely in the large plants. Meters for this use are generally of a higher degree of accuracy than those mentioned heretofore and are generally of the indicating type, whereas those already mentioned are generally of the recording type.

Meter Maintenance

Meters which are out of order and inaccurate are worse than useless. Practically all power plant meters require periodical attention to keep them in satisfactory operating condition and the methods of bringing this about have been unsatisfactory in numerous cases. Meters which are put under the care of a boiler room foreman or repair man with other duties often become unserviceable in the course of a few months and soon after are worth so much scrap. The main reasons for this are that meter maintenance requires more study than most of these men have time or training to master and that these men often prefer the meters out of order, as their tasks of boiler operation, cleaning, etc. are then (to their minds) much simpler.

As mentioned previously, it is now almost universal practice to place the responsibility of meter maintenance on one man who reports directly to the superintendent of the plant. As meter maintenance and test work have a great deal in common, the duty of carrying on both classes of work is often given to one man in small plants and one man in charge of a test department and meter department in large plants. Dividing the responsibility of meter maintenance among a number of test men is advised against. The advantages of a separate meter department are that the promotion of the man in charge depends on the thoroughness with which he keeps the meters in operating condition and that the work being distributed among the minimum number of men, they become experts.

Due to the importance of accuracy, the schedule of inspection on each meter should be such that it is never out of order except when it is due to breakage. This sounds like saying that fire engines should be inspected just before each fire, but a system which has nearly achieved this ideal is as follows. Each meter, as it is installed, is given a preliminary schedule of inspection and repairs. After each inspection the condition of the meter before and after inspection is placed on record. These records are checked from time to time and the period of inspection increased or decreased according to the record. The advantages of this system are that the desired result is achieved in the minimum time and that the character and value of each meter is shown by the record.

Venturi meters are usually overhauled thoroughly about four times a year, given a manometer check monthly which includes blowing out the pipe lines. CO_2 recorders are usually set daily with an Orsat apparatus. The Bailey boiler meter requires setting about four times a year. Important thermometer recorders (feed water, steam, etc.) are usually set monthly, others of less importance are usually set every two or three months.

(In the July 1 issue, Mr. Zimmerman will present a discussion of the various types and characteristics of meters commonly used in power plants.—Editor.)

Diesel Engine Fuel Valves---IV*

VALVES USED ON HORIZONTAL ENGINES. SPECIAL VALVES FOR HEAVY OILS. BY H. F. BIRNIE AND R. C. BAUMANN

HORIZONTAL engines are most frequently equipped with valves of the so-called "open type." The principal differences between the open and closed types are brought out by Figs. 1 and 2. Figure 1 shows the inner end of a closed valve adapted for horizontal service while Fig. 2 shows an open valve for the same conditions of operation.

In the valve of Fig. 1 the fuel oil is pumped into the annular chamber about the fuel needle against the full pressure of the injection air. In the open valve of Fig. 2, the fuel oil is pumped through the channel C into the well E during the intake stroke of the piston or before compression has advanced. Since the minute well chamber into which the oil is pumped is always in communication with the combustion chamber through the passage D,

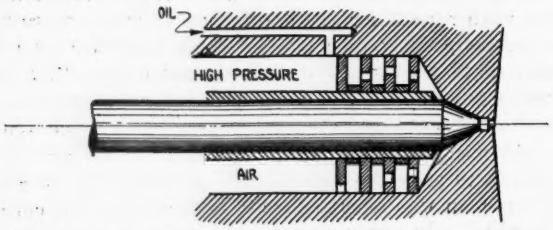


FIG. 1. INNER END OF A CLOSED VALVE ADAPTED FOR HORIZONTAL SERVICE

the fuel pump must overcome only the pressure existing in the working cylinder and not the pressure of the injection air which is much higher. In the open valve, injection does not start until the air valve B opens and allows blast air to strike the surface of the oil charge in the well E and carry it into the combustion chamber. The restricted nozzle opening into the combustion chamber is relied upon to effect atomization.

One advantage of the open valve is that the fuel pump does not have to deliver against the high pressure of the blast air, hence it may be of lighter and cheaper construction and it is easier to keep free from leaks. The open valve, however, is more liable to become clogged by carbon deposits in and about its nozzle than the closed valve. Carbon deposits will tend to form rather quickly if the air valve B is not kept perfectly tight. On the other hand, the air needle of the open valve is more easily kept in good condition than the needle of the closed valve since only air passes its seat and not air and fuel. The open valve design is used in this country on Allis-Chalmers, National Transit and Worthington-Snow horizontal engines.

Horizontal valves of the closed type are also used but not extensively. In such a valve the perforated atomizing plates must be especially drilled to overcome the influence of gravity upon the fuel, which makes it difficult to obtain even distribution of the oil charge in front of the injection air blast. One method of attacking this problem is to drill the first atomizing plate only at the bottom where the fuel collects. The second plate is drilled only near the top and finally the last plates are drilled about their whole circumference as in the plates of vertical closed valves.

SPECIAL INJECTION VALVES

Under this classification come valves of modified design especially designed to handle tar or heavy petroleum residue oils.

Coal tar oils are characterized by exceedingly high spontaneous ignition temperatures and it is this property which is responsible for the difficulty encountered in burning them successfully in Diesel engines. The temperature of spontaneous ignition of coal tar distillates will average about 900 deg. F. as compared to the corresponding temperature of 510 deg. F. for petroleum oils.

If the compression pressure of the engine is raised to about 600 lb. per sq. in., the engine can be run on tar oils without special injection valves after it has been started

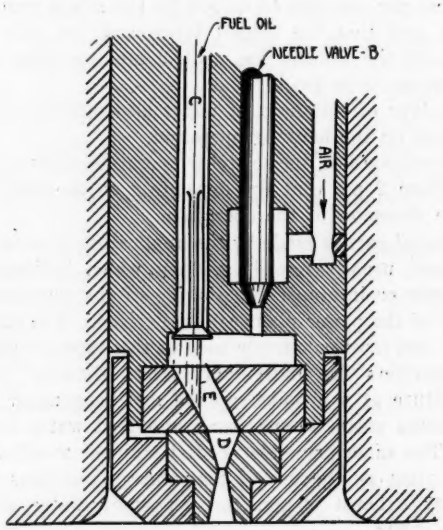


FIG. 2. OPEN TYPE VALVE FREQUENTLY USED ON HORIZONTAL ENGINES

and warmed up on petroleum oil; however, this compression is hardly desirable, hence for practical service this expedient must be abandoned. Another expedient is the use of hot blast air; that is, the injection air is taken direct from the last stage of the compressor to the injection valves and not run through after coolers. This allows the use of a compression pressure of as low as 525 lb. per sq. in. but since there are objections to the use of hot blast air and since it is not entirely effective when using all grades of tar oil, this method has also been abandoned.

The final solution of the problem has been the use of a small pilot or ignition charge of petroleum oil which is injected just ahead of the main charge of tar oil. One of the earlier and most simple valves for accomplishing this progressive injection of two different grades of oil is illustrated in Fig. 3. The tapered portion of the valve needle is grooved, thus in effect producing two separate valves one above the other. The small pilot charge of petroleum oil is pumped into the annular groove space A by a small separate constant delivery pump while the charge of tar oil is

*Part I appeared March 15; Part II, April 1, and Part III May 1.

deposited at the same time upon the top atomizer plate by the main metering pump. When the valve needle lifts, the small charge of petroleum oil precedes the tar oil into the combustion chamber and serves to initiate combustion so that the temperature of the cylinder gases is raised well above the spontaneous burning temperature of the tar oil before the latter reaches the cylinder.

Gumming Causes Trouble with Tar Oil

Another difficulty encountered when burning tar oils is the clogging or gumming of the pulverizer or atomizer plates by a sticky residue which is thrown down from the tar distillates. For this reason the sleeve atomizer is used when burning tar oils in preference to either the conventional plate atomizer or the Hesselman valve. One type of sleeve atomizer is illustrated in Fig. 4.

Tar oils are not obtainable at the present time in this country in sufficient quantities to allow of their extensive use as fuel oil. They have been mentioned here only to call attention to the wide range of fuels which a Diesel engine can be adapted to burn. It was formerly thought impossible to burn tar oils but experimentation has been so

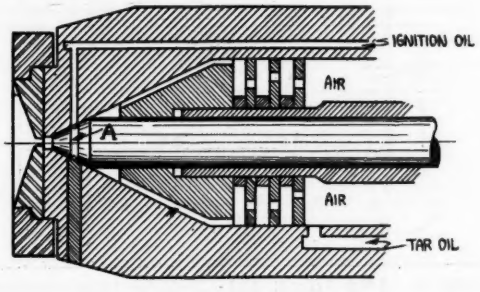


FIG. 3. AN IGNITION OIL IS SOMETIMES INJECTED AHEAD OF TAR OIL

successful that they are now burned as one of the principal Diesel fuels in Germany and England.

Valves for Petroleum Residue Oils

Of much more interest is the problem of burning heavy American petroleum residue oils. These oils are the heavier byproducts of refining processes for obtaining gasoline and the lighter and more volatile fuels and hence are cheaper than standard Diesel fuel oil and are easily and readily obtained in some parts of this country. These heavy residues are sometimes erroneously referred to as crudes. Crude oil is much lighter than the residues and is seldom obtainable for fuel purposes, as the gasoline content makes it too valuable to the refiner. Crude oil usually has a gravity higher than 30 deg. Bé. while the heavy residues have a gravity of 14 to 16 deg. Bé. Regular Diesel fuel oil ranges from 20 to 26 deg. Bé.

The residues referred to are the heavy fuel oils sold on the American market under various trade classifications the most familiar one being "Bunker C." These fuels are characterized by high specific gravities and by very high viscosities at ordinary temperatures. Their heat content is low, being usually between 17,000 and 17,500 B.t.u. per lb. as compared with 18,500 to 19,300 B.t.u. for standard Diesel fuel oil. They often contain much sulphur, water and solid foreign matter. Oils of this character are successfully burned by one American manufacturer in his larger and slower speed engines while a second American manufacturer has been so successful that he can guarantee operation on engines as small as 13 in. bore and at speeds of 270 r.p.m.

The valve most suited for heavy residue oils is the conventional closed plate type. No changes or departure from the regular design will be found necessary other than the careful selection of the atomizing plates, cone and

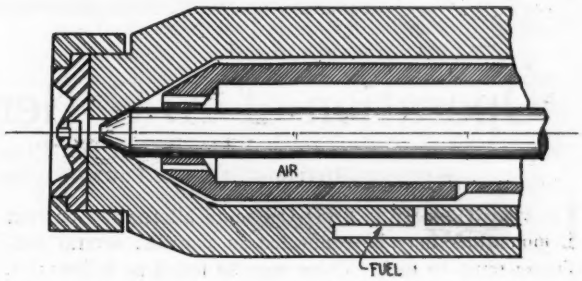


FIG. 4. SLEEVE ATOMIZER BETTER THAN PLATE ATOMIZER FOR TAR OILS

nozzle plate. The problem is principally one of reducing the viscosity of the oil to a point where it becomes fluid enough to be readily handled by fuel injection pump and injection valve. This is brought about by heating the oil to temperatures of 180 deg. F. and higher.

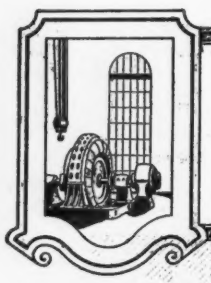
Too Many Types of Manholes

GROWING municipalities have a perennial problem in the extension of pavements, sewers, gas and water mains and conduits for telephone and electric distribution. One side of the problem is the burden imposed on the foundries and indirectly on the taxpayer by the "57 varieties" in sizes, dimensions, styles and patterns of manhole tops and covers. The suggestion that varieties be simplified to a few patterns and sizes has been made to the Division of Simplified Practice of the Department of Commerce by a prominent industrial engineer, now consultant to a group of west coast foundries. He points out that no two cities in his area use the same type or size of these commodities and shows how this over-diversification makes it difficult for his clients to handle this class of work economically.

Some of the producers recommend reduction to a few common patterns and sizes. Such a simplification would enable out of town foundries to compete with local plants and broaden the sources of supply for the departments of public works. Similarly the foundries would find their markets broadened by being able to bid on work for several communities at one time. Pattern costs now charged to a particular design might be spread over a larger volume of orders with economies to the foundrymen, lower prices to the consumer, and greater value for the taxpayer's dollar.

Another phase of the problem is the relatively low grade of material used in manhole construction. These are often made from scrap iron and a large loss comes through breakage in production which must be absorbed in the price of good pieces delivered.

Because of the interest shown and the suggestions already received by the Division, it is planned to call a preliminary conference in the near future to develop simplified practice recommendations covering manholes.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Operation of A. C. Generating Apparatus---V

CONDITIONS NECESSARY FOR PARALLEL OPERATIONS, SYNCHRONIZING, DIVISION OF LOAD, POWER FACTOR CORRECTION. BY V. E. JOHNSON.

IN ORDER THAT TWO OR more alternating current generators may be connected in parallel, several conditions must be met. These may be listed as follows: 1. The machines must have the same frequency. 2. The voltage must be approximately the same on all machines. 3. The synchronizing switch must be closed at a time when the generators are exactly in phase. 4. The governors of the prime movers must be capable of suitable speed adjustment in order that load division may be obtained.

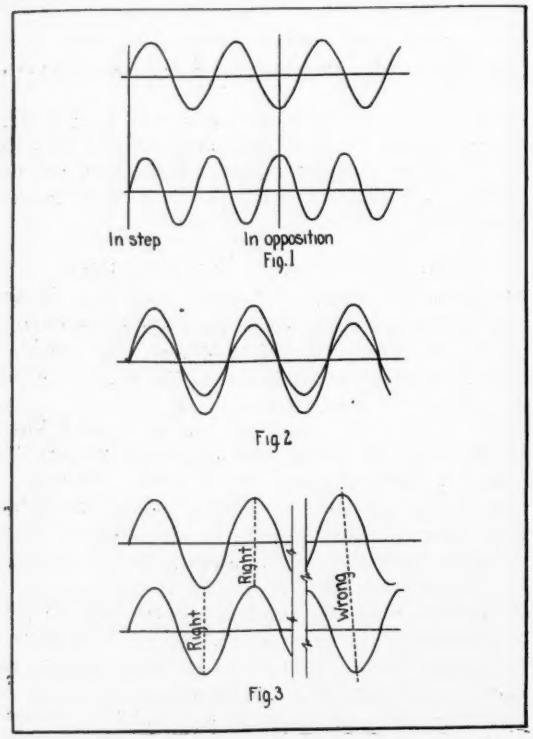


FIG. 1-3. WAVE DIAGRAMS SHOWING CONDITIONS TO BE MET IN PARALLEL OPERATION

In the operation of direct current machines in parallel, one of the principal requirements is that the polarity must be correct. This applies with equal force to alternators, for if they are not connected so that the instantaneous polarities of the various machines are the same, the result is virtually a short circuit upon which is impressed double voltage.

Figure 1 represents the voltages of two generators of slightly different frequency. It is evident that although the two waves are practically in phase during the first alternation, the displacement between them increases rapidly to 180 deg. in the first half at the second cycle. If these two machines were connected in parallel they would run together for a brief period and would then go into a short circuit condition, provided the speed of each machine remained constant. As a matter of fact, the current that would flow between them due to the displaced phase relations would strongly tend to equalize the frequencies, slowing down the higher speed machine and speeding up the slower one.

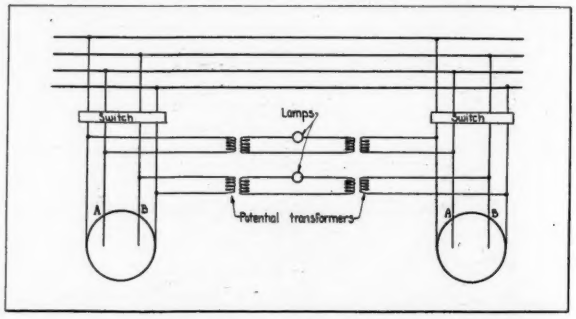


FIG. 4. TWO PHASE ALTERNATORS IN PARALLEL

The reasons for the second requirement, that of having equal voltages, is explained by Fig. 2. Here are shown the waves of two generators which have equal frequencies and are in phase, but which have unequal voltages. It will be noticed that the difference is greatest at the maximum points. The result of this condition would be that a circulating current would flow between the machines. This current would lag behind the voltage of the higher machine, demagnetize its fields and simultaneously increase the voltage of the lower machine. Inasmuch as the machines are connected together, they must necessarily have equal terminal voltages; it follows, then, that enough current will flow to establish this balance.

PROPORTIONING THE LOAD

Assuming that the generators to be paralleled are running at equal frequency and voltage, it is essential that the connecting switch be closed at a point when the waves of both machines are in step. This means that the conditions must be as shown in Fig. 3. However, if the generators were slightly displaced at the instant of connection

the synchronizing current flowing between the machines would pull them into step.

Raising or lowering the excitation on either machines after they are running in parallel causes an exchange of current between them. If an external load is connected to the busses, altering the excitation may cause also a rearrangement of the current between the machines and the load. In neither case, however, will rheostat manipulation have any effect on the division of the load in kilowatts. Load can be transferred from machine to machine only by adjusting the governors of the prime movers. Engineers frequently fail to understand this and attempt to divide the load between the engines or turbines by weakening or strengthening the generator fields.

Phase Relations

To the four conditions which have been given as governing the parallel operation of generators, a fifth one is added when polyphase machines are under consideration. Thus in a two-phase machine, consisting as it does of virtually two single-phase windings displaced mechanically to give a 90-deg. phase angle between the resultant voltages, it is essential that both phases be in step.

In Fig. 4, if one synchronizing lamp were connected across the A phase in machine No. 1 and B phase in machine No. 2, it is evident that the other phase would

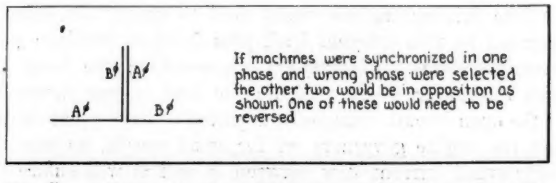

B
A
A
B
If machines were synchronized in one phase and wrong phase were selected the other two would be in opposition as shown. One of these would need to be reversed

FIG. 5. VECTOR DIAGRAM SHOWING IMPROPER PARALLEL CONNECTIONS

be out of step. This is even more plainly seen in the vector diagram in Fig. 5.

In order to establish the proper phase relation between both pairs of phases, it is necessary to use lamps or other means for checking simultaneously the conditions in both circuits. Once correctly connected, one set of synchronism indicators is enough.

Similarly, in three phase systems, it is necessary to "phase out" the generators in order to determine the sequence of the phases. Similar machines manufactured by the same company have tags on the leads which may to some extent serve as a guide, but this is at best a rather unreliable means of determining phase relations.

In Fig. 6 is shown the method of determining by means of lamps that the proper phase sequence exists. If the relation is correct, the two lamps (or sets of lamps) flicker in unison. If the phase relation is wrong, the lamps do not vary their brilliancy together, but instead one of them gets bright as the other darkens. When this is the case, it is necessary to reverse one pair of leads on one machine. When this has been done it will be seen that the lamps vary in unison, and that the machines are therefore "properly phased out." It is now sufficient to use lamps or a synchroscope in one phase only, as with this one in step, the others must follow. However, if the direction of rotation of either machine be changed, this will throw them out of phase again.

Another method is to connect an induction motor first to one generator and then to the other, using care that the motor leads go to corresponding terminals on the two machines. If the motor runs in the same direction from either source, the phase relation is right and a synchronoscope in one of the three phases will be sufficient.

There is an exception to the above rules for determining and correcting the phase relations. If the two generators are rigidly connected to each other—either through a shaft or through synchronous motors running in parallel off the same bus, the foregoing cannot be applied without modification. In this case it is necessary, not only to obtain the proper sequence of phases, but the windings which occupy corresponding positions in the stator must be connected.

Sometimes conditions arise in which it is impossible or undesirable to use conventional methods of synchroniz-

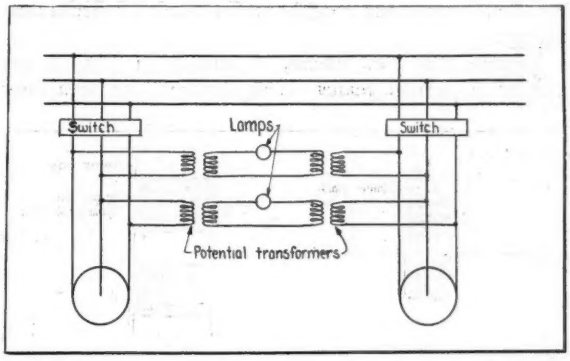


FIG. 6. METHOD OF DETERMINING PROPER PHASE SEQUENCE

ing, as described above. In automatic power houses, small units are thrown on the line unexcited, and the field closed an instant later. Machines of this kind are provided with heavy damper windings which limit the rush of current.

Emergency Methods of Synchronizing

Sometimes it happens that, due to accident, the synchronizing apparatus is inoperative. If the phase relations of the apparatus are known to be correct, it is possible as an emergency measure to get even quite large units into service by the following method:

The unit is first brought to full speed, and this is carefully checked with a tachometer or other means. The field is left short circuited through the discharge resistance. The main switch is now closed. There will be a considerable rush of current, but under ordinary circumstances this will do no harm. Lastly, the field switch is closed, and normal excitation applied.

If only two generators are involved, they can be brought up to speed together, with their fields excited and the main switch closed. This prevents any excessive flow of current, and is a safe method.

Two alternators operating in parallel must necessarily run at exactly the same speed. Even a variation between them of one revolution per hour would mean that they would periodically be in opposition.

Not only must the revolutions be equal in number, but the two generator waves must be kept within a few degrees of each other. This means that machines with a large number of poles can have only an extremely small mechanical displacement.

They must run in unison to a remarkable degree, for not only must each revolution be completed simultaneously, but every cycle must begin and end at the same instant.

The alternators are virtually coupled directly to one another, and are held so by the current which circulates between their stators.

The slight angular displacement permissible between them is analogous to the mechanical displacement which occurs when a flexible coupling is used. In the latter case, there is a slight relative motion between halves of the coupling, which corresponds to the instantaneous disagreement between alternators when running in parallel, and held in step electrically.

If two machines as A and B, having exactly equal voltages, are connected in parallel, and A for example drops behind B, say 10 electrical degrees, there will be a resultant voltage difference which will cause a current to circulate, and it is this that ties the machine in step. The effect is explained roughly by the following mechanical analogy:

Assume that two wheels, A and B in Fig. 7, are running in parallel planes—close together, and with their

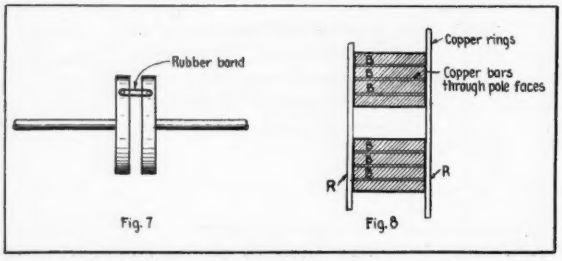


FIG. 7. MECHANICAL ANALOGY TO SHOW HOW ALTERNATORS KEEP IN STEP

FIG. 8. SHOWING USE OF DAMPING WINDINGS ON ALTERNATORS TO PROVIDE ADDITIONAL PULL

shafts in a straight line. If a rubber band be attached from the rim of one to the rim of the other, and its length be such that it normally is under tension, this band in a sense corresponds to the magnetism in the rotors and stators of the two generators. If the wheel A should run a little ahead of B, the band stretches, and by its increased tension pulls A back and B forward until the speeds become uniform again. The elasticity of the rubber would permit instantaneous deviations in speed, but these would be within the elastic limit of the band. If the speed continues to be different for more than an instant, that is, if A continues to run away from B, the band will break. Similarly with the generators, if the speed difference continues, the synchronous relations will be broken and the alternators will drop out of step.

We have previously outlined the difference between electrical and mechanical degrees. In a two-pole machine the electrical degrees, measured mechanically around the stator, are the largest.

If we assume that a displacement of ten electrical degrees is permissible, a two-pole machine could vary 1/36 of a revolution, or about 3 per cent. On the other hand, a generator having 120 poles could vary only 1/2160 of a revolution ($1/60 \times 1/36$) or roughly 0.05 per cent.

From this it is seen that, other things being equal, it should be easier to operate high-speed machines in parallel, these having fewer poles. There are, however, some other characteristics that reduce the advantage of the high speed units. These will not be treated here.

When generators are driven by gas engines, or other prime movers which have an irregular turning moment at different parts of the stroke, it sometimes happens that the synchronizing power of the stator currents is not in itself sufficient to hold the machines in step. To provide additional "pull," a separate winding is provided. This is known as a damper winding and consists of a variety of coils or grids attached to the pole faces, as in Fig. 8, which shows a face view of two of the poles. The rings R go all the way around the rotor, while the bars B pass through the pole face. Any deviation in speed causes currents to be induced in these bars and rings, setting up a magnetic flux which assists the main magnetism to hold the generators in step. Referring to our mechanical analogy of the rubber bands, this is equivalent to adding some more rubber strips; these latter being "slack" so that no pull is exerted by them except upon actual movement of the wheels relative to each other. Thus, the internal synchronizing current flows due to a phase displacement, while the damper winding current flows as the result of a relative movement between the rotors of the machines operating in parallel. In case of alternators driven by oil or gas engines, these damper windings are very necessary.

Let us now consider more in detail the action of two generators in parallel under various conditions of load and field. Assume two machines as A and B in Fig. 9 running in parallel on a bus, and having a load connected as shown.

The driving engines would need to supply the energy required by this external load, plus friction, windage and electrical losses. Wattmeters connected in the leads of each alternator would indicate the load it was carrying. If the open circuit voltages be adjusted to have equal value, and the engine governors set for equal speeds, an exceedingly small current flow between A and B will suffice to hold them in step. If the steam on B be shut off, it will continue to run as a synchronous motor, while A will supply the load and the losses in both generators. Similar results will follow if A be "speeded up." Adjusting the prime mover governor will transfer the load to either machine, at the will of the operator.

As the terminal voltages, as well as the speed, necessarily must be equal on the two generators, the only possible variation between them can be in the phase angle between the generated pressures. It can be shown mathematically that the total load on a generator under constant terminal or bus voltage conditions varies very nearly in direct proportion to the angle between the generated and terminal pressures.

If the generator A be small in relation to B, or if there are enough other machines connected to the same bus, variations in A's voltage or power output will have very small effects on the voltage or frequency of the system. Admitting more steam to A's engine will tend to force it ahead, and will, so to speak, "stretch" the magnetic lines of force—just as increasing the power applied to one of the wheels in Fig. 7 would stretch the rubber band, and the net result is that the generator will assume a greater portion of the total load.

If the steam conditions be constant, and the field strength varied, A's stator current will vary, but the kilowatt load will remain unchanged. This statement can easily be verified by actual experiment.

Under constant voltage and load the magnetic flux is of approximately constant value—regardless of other conditions. This magnetism is the resultant of the rotor flux

produced by the exciting current and stator flux due to the load currents. If the field be weakened, the change is compensated for by the stator currents. For example, if the excitation be reduced below normal, a stator current will flow—which will lead the voltage and so aid the rotor flux. If on the other hand the field be increased above normal, sufficient lagging current will flow to reetablish an equilibrium. These leading or lagging currents which are set up in response to field manipulation, are called magnetizing and demagnetizing respectively, and constitute the so-called wattless component which has previously been mentioned.

If the field be excited exactly right, these wattless currents may to a large extent be eliminated.

The above explanation can be readily grasped if we experimentally determine the effect of field changes in a generator having constant load and terminal voltage. This can readily be done by varying the fields of two generators (as A and B above) simultaneously but in opposite direc-

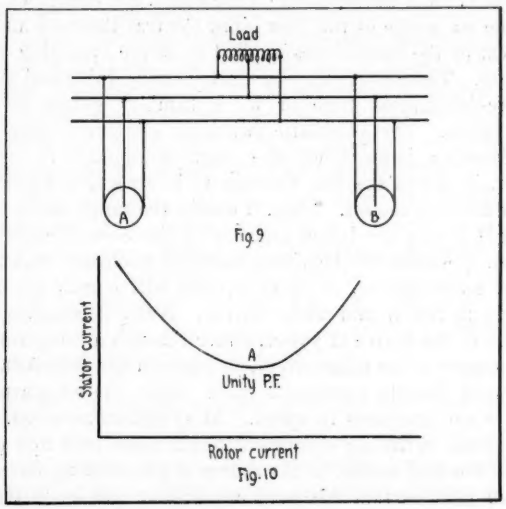


FIG. 9. TWO 3-PHASE ALTERNATORS CONNECTED TO A COMMON LOAD

FIG. 10. CURVE SHOWING VARIATION OF STATOR CURRENT WITH ROTOR CURRENT

tions. For example if A's field be strengthened, the bus voltage must be returned to normal by reducing B's excitation. If A is a very small proportion of the total connected capacity, it is often unnecessary to manipulate any other rheostats, the voltage remaining constant automatically. As the field is increased, the stator current decreases, until a minimum power is reached. Further increase of the field causes the stator current to increase. The result can be plotted in a curve similar to Fig. 10. At the minimum point there is no wattless current, and that particular machine is operating at 100 per cent power factor. If the external circuit is reactive, so that its power factor is less than 100 per cent, then the other generators are supplying all of the wattless current required by it.

It must be borne in mind that if one generator alone is supplying the load current, a curve as in Fig. 10 can not be obtained, as it would then be impossible to maintain constant bus voltage. However, if this single generator have a load consisting largely of synchronous motors, these can be manipulated to maintain the terminal pressure constant.

We have seen that the wattless current required by an electrical system can be supplied from any generator, at the will of the operator. It can also be supplied from any synchronous motors connected into the system by manipulating the motor field exactly as though it were a generator. A curve such as shown in Fig. 10 can be obtained on a synchronous motor, under the same conditions as was previously obtained on an alternator—namely constant load and voltage. At the point A it would take sufficient current to carry the mechanical load, and would operate at 100 per cent P. F. with excitations greater than that at the point A, it would take a leading current from the line, and conversely with a weaker field would take a lagging current. This is essentially equivalent to saying that an over excited synchronous motor supplies a magnetizing current to the line which compensates for lagging power factor. In other words, in a system having sufficient capacity synchronous motors, the entire wattless current taken by the load, can be supplied by them, thus leaving the generator to operate at 100 per cent P. F.

In connection with the preceding discussions it must be borne in mind that a given system will require a definite magnetizing or charging current, dependent upon the various units of which it is composed. The station power factor will be determined by the character of the various circuits it feeds. If a given net work requires say N amperes of magnetizing current; or, expressed differently, K wattless kv.a., this must be supplied from some source. The total wattless kv.a. may be divided between the generators—or may be supplied by synchronous phase modifiers—but it can not be eliminated. The wattless current may however, be supplied at a point distant from the power house—and so relieve the cables of that portion of their load.

Belts and Belt Dressing

WHERE LEATHER BELTS are in a dry, warm place they require some oily dressing to keep them pliable and to make them grip. A belt allowed to become dry will become weak and will wear out far sooner than it ought. Putting dry powdered resin on a belt in this condition to make it pull is a bad thing for the belt, as it dries it out still more.

Some animal oil, "neat's foot," for instance, is probably best, though castor oil has many friends. Do not use too much. Where a belt is soaked with oil it gives trouble by slipping and running off. Such a belt may not transmit half the power it should. Something to absorb the oil from the belt is wanted. Powdered chalk will probably make the belt pull its load again. Keep the lumps scraped off.

A good liquid dressing for summer that will keep the belts pliable and in good condition for work is: Beeswax 4 lb., pitch 5 lb., resin 3 lb., neat's foot oil 13 lb.

Melt the beeswax first and add the other ingredients in the order named. For winter use 15 lb. neat's foot oil instead of 13. Dress the belt both inside and outside. Be careful not to use too much dressing.

IT IS REPORTED that Holzworth gas turbines are now ready to be marketed. Following tests of experimental machines, a 700-kw. gas turbine and a 300-kw. oil turbine have been put in operation and a 5000-kw. gas turbine is nearly ready for commercial service.

Automatic Substation for Industrial Plants*

AUTOMATIC OPERATION GREATLY EXTENDS FIELD OF USEFULNESS OF CERTAIN CLASSES OF ELECTRICAL APPARATUS. BY CHESTER LICHTENBERG

AUTOMATIC ELECTRIC substations have been used to a greater extent by railways and by central stations than in the industrial field. Nevertheless, the most promising field for automatic substations seems to be in the transformation and supply of electric power for all sorts of industrial purposes.

Generally, some form of power-transforming equipment is utilized in industrial enterprises. It may be rotating equipment such as transformers, static condensers or merverters or synchronous condensers, or it may be static equipment such as transformers, static condensers of mercury tube converters.

Synchronous condensers form one of the simplest classes of rotating machines to which automatic station

FIG. 1. UNITED RAILWAYS CO. OF ST. LOUIS, FRANKLIN AVE. SUBSTATION

control equipment has been applied. They also form a class of power conservers which industrial organizations seem hesitant to adopt. It may be that heretofore the need to provide them with an operator has retarded their location at strategic points on the power network, or forced their location in existing attended stations which were remote from the preferred point for best performance. Whatever the reason may have been, the successful automatic operation of these units has widely extended their field of application, particularly to electrified industries.

AUTOMATIC CONTROL OF SYNCHRONOUS CONDENSERS

The automatic control of a synchronous condenser is relatively simple. The starting impulse is given by any one of several familiar devices. A voltage relay, a power-factor relay, a time clock or simple tumbler switch may be used to start the set. The synchronous condenser is usually provided with an amortisseur winding and is brought up to speed as an induction motor. A compensator or Y-delta starting scheme may be used, either being readily adapted to automatic control. Usually during the period of acceleration, the synchronous condenser field remains disconnected from the source of exciting current and is bridged by a field-discharge resistor. This aids in giving the required starting and pull-in torque. After its field is excited, the unit has been connected to the line and full pressure applied to its windings, it begins to function as a power-factor corrector. A power-factor regulator or a voltage regulator which forms part of the automatic switching equipment adjusts the field current automatically to maintain either fixed power factor or fixed pressure within the limits of operation of the unit.

SYNCHRONOUS MOTOR GENERATORS

Synchronous motor generators form the next general class of rotating electrical machines which have been successfully equipped with automatic switching. Units of 150 kw. in capacity are now operating in many sections of the coal mining district and are typical of the smaller sizes. A 2000-kw. set is in operation on the 666-v. d.c. electrification on the main line of the New York Central Railroad and is typical of the larger sizes applied to severe operating conditions. These units may be started on load demand or at a pre-determined time or by a tumbler switch or its equivalent. The automatic switching equipment proceeds to function immediately the starting impulse is given. First, it checks the line pressure to be sure it is ample to start and run the set. Next, it checks the supply to be sure all the phases are intact and are of the correct sequence. Then, it checks the bearings, machine windings, and ambient temperatures, to be sure these will permit the machines to run if and when started. Next, it connects the motor to the source of power, either through a compensator or to taps on the transformer, or through the transformers direct if Y-delta starting is used. Then the set starts to rotate and increases in speed. At synchronous speed, the automatic switching equipment again takes hold and connects the field circuit to the source of the exciting current. When field current has been established, the set is transferred from the starting combination to the running combination. During the accelerating period the motor field remains disconnected from the source of exciting current and is bridged by a resistor in the same manner as is the synchronous condenser during its starting cycle. This permits individual adjustment of each motor so as to obtain a complete start under practically all conditions which can be found in service.

The d.c. generator is provided with protection and adjustment, depending upon the service requirements to which it will be subjected. The simpler equipments, which may be shunt or compound wound, are usually operated with a fixed shunt-field setting. This setting is chosen to give the desired terminal pressure, and in the case of multiple-unit sets, must be carefully adjusted to give the correct loading of the machines. Multiple-unit stations also require careful compounding of the units to permit the successful multiple operation of "hot" and "cold" machines.

The d.c. generators of larger sized sets are frequently provided with automatic load regulation. One type is provided with a shunt-field bucking scheme. This has been successfully applied to shunt-wound generators for multiple-pressure booster service. The shunt-field current is normally furnished by the generator itself. The current is then passed through the armature of a tiny motor-generator continuously rotating. This set, by a suitable raising

*Paper delivered at the Spring convention of the A. I. E. E.

or lowering of its field current, bucks or boosts the shunt-field current of the generator the correct amount and gives the desired regulation. In one example, using this method of control, load swings of from 300 per cent normal to 200 per cent reversal are successfully handled.

Another modification is a compound-wound d.c. generator with the series field connected to oppose the shunt field. This type of generator is usually operated with the series field shunted by a circuit breaker which allows only a fraction of normal current to flow through the field when it is closed. Under heavy overload conditions, the circuit breaker is automatically opened and the series field carries the full line current. As soon as the overload condition ceases, the circuit breaker automatically recloses and shunts the series field. Under this condition it tends to oppose the shunt field. Now suitably proportioning the shunt and series fields, the d.c. generator can be made practically a constant-current machine and service may be maintained at a reduced pressure during emergency load conditions. A number of such equipments are operating on the Edison three-wire networks of many of the large electricity supply corporations, and their use is being rapidly extended. Their judicious application to electrified industrial establishments would insure continuity of service under the most severe conditions short of complete and sustained interruption of primary electricity power supply.

The automatic switching and control of synchronous converters invariably assumes the a.c. supply to be available before any starting operations are performed. Consequently, all automatically-controlled synchronous converters are invariably a.c. starting. Also, with one or two minor exceptions, the starting is acomplished with the aid of an amortisseur winding on the field.

Starting the Automatic Synchronous Converter

The starting indication for an automatic synchronous converter may be any one of the usual devices, such as a pressure relay, a time switch, a tumbler switch, or their equivalent. Immediately the starting impulse has been completed, the synchronous converter is connected to the starting taps on the power transformer. One-third taps or one-half taps, depending on the design of the synchronous converter and transformers, will usually furnish sufficient torque to start the converter armature and pull it into step. Then the converter is automatically transferred from the starting taps to the running taps.

During the starting operation, the shunt field is usually opened. After the machine has reached synchronous speed, its field is either flashed with the correct polarity before it is made self-exciting, or its field is reversed until correct polarity is established.

The next step in the process is to connect the synchronous converter to the d.c. network or feeder, and here the inherent characteristics of the converter require a different series of operations than do motor-generator sets. The d.c. terminal pressure of a synchronous converter is regulated largely by the a.c. pressure-supply. Only a relatively narrow range of d.c. terminal-pressure adjustment is possible by field adjustment. This then requires some arrangement for safely connecting the synchronous converter to the d.c. network, even though that network may be operating at a pressure quite different from the terminal pressure of the synchronous converter. This condition is most usually encountered in all sorts of electric haulage installations, since here the wide swings in power demand are very large compared with the feeding capacity of the a.c. supply. For electric railways and commercial electric power service generally, and sometimes for industrial electric power supply, synchronous converters are equipped with load-limiting resistors. These are connected between the d.c. terminals of the synchronous converter and the d.c. network or feeder after the synchronous converter has been placed in complete running condition insofar as the a.c. side is concerned. These resistors are then usually shunted out in two or three steps thus gradually loading the synchronous converter from the d.c. network. The shunting contactors or circuit breakers used for this service are usually provided with current relays having interlocks so that the synchronous converter cannot be loaded beyond its thermal capacity. Other devices such as thermostats, located near the load-limiting resistors, permit the synchronous converter to supply current to the d.c. system within safe heating limits until the load is reduced or the resistors and converter tend to overheat dangerously. Under these conditions, the converter is automatically shut down until it and the resistors cool. After the equipment has cooled sufficiently, a fresh start is automatically made. In some cases the load-limiting resistors are shunted out in only one step where economy in design and manufacture permit Y-delta starting. With this combination and with suitable transformer design, the Y-delta arrangement may be used to take the place of one step of the load-limiting resistors.

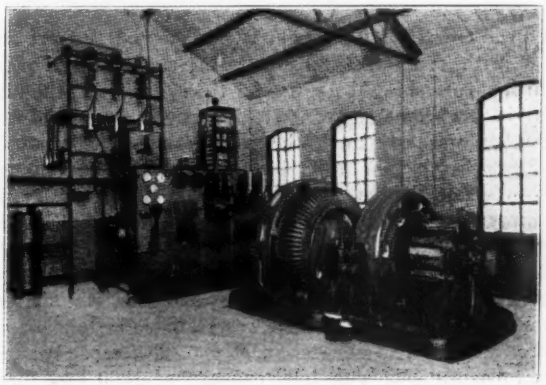


FIG. 2. 300 KW. SYNCHRONOUS MOTOR GENERATOR WITH AUTOMATIC CONTROL EQUIPMENT, CLEARFIELD BITUMINOUS COAL CORPORATION, ROSSITER, PA.

The load-limiting combination available for, and used with, synchronous converters permits their wide application to all sorts of electrified industries as well as to electric railway and electric power supply systems. It permits the use of the economical synchronous converter in many places where motor-generator sets were formerly considered supreme. For certain few applications, they are excelled only by specially designed motor-generators with automatic load-regulating features.

Synchronous converters for automatic operation are provided with the usual automatic station protective features such as bearing and resistor temperature relays, short and long-time continued a.c. overload relays, single-phase starting preventive and harmful continued single-phase running preventive relays, low a.c. pressure starting or operating preventive relays, overspeed switches in combination with a shunt trip circuit breaker, leakage to ground relays, etc.

Other electric power-transforming machines, such as balancers, mercury tube converters, and static transformers have been made completely automatic and are now in successful operation. Their design usually takes pattern after the best manual operation scheme, except that the time for the switching is generally reduced from a matter of minutes to a matter of seconds.

The automatic hydroelectric plant is one of the outstanding applications of automatic switching equipment to industrial enterprises. Consider, for example, the many streams of moderate size but relatively uniform flow which are found in the upper Middle West. They have been used for many generations to drive grist mills of quite good size, as well as performing many other industrial functions of varied natures. The hydro equipment which has heretofore been used is fast becoming antiquated and the output of the mills is suffering in consequence. The recent installation of automatic hydroelectric equipments in a number of these mills has wrought an important change in this section of the country. The same streams now permit not only a greater mill output in combination with the electrification of the mills, but also provide an inexpensive power supply to adjacent towns and villages. More important even is the fact that the electrified mill can now be connected to the large electric power supply system covering the country, and can either take power from this system during times of low water or can feed power into the network during times of high water.

Power at the Wembley Exhibition

Exhibit Plant Which Will Furnish Current for the British Empire Exhibition in London

NOT OF GREAT size but of considerable interest and with many features worthy of study is the plant which is furnishing the power for the exhibits and the railway in the Wembley grounds. Maximum demand of 10,000 kw. was estimated, the engineering and industries exhibits calling for 2400 kw., colonial and government exhibits for 1600 kw., amusements for 1350 kw. and the railway for 750 kw., the remainder being used for lighting and miscellaneous purposes in grounds and restaurants. It was considered that an installation for 7500 kw. rated capacity would care for the load and this was divided among the three sources of power available as follows: A turbo-alternator steam station of 4500 kw. capacity; four reciprocating sets with total capacity of 1000 kw., direct current; an a.c. substation of 2000 kw. capacity, drawing current at 11,000 v. from the Northern Metropolitan Power Co.'s mains.

General Supply

General supply for the exhibition is three-phase, four-wire, a.c., at 415 v. across the mains for power and 240 v. from outside wires to neutral for lighting. Direct current is supplied on the three-wire system with outside voltage of 440, all generators feeding into a network which can also be supplied from a standby of three rotary converters, two in the substation and one in the space of an exhibitor.

Two boiler units are installed, one by Babcock and Wilcox, Limited, the other by John Thompson Water Tube Boilers, Limited, each unit being installed independently with its own economizer, flue, induced draft plant and stack. Coal comes to both units from a common overhead bunker, ash goes to a common conveyor system and steam is delivered to a common main.

Three turbine units are provided, of 1500 kw. capacity each, running at 3000 r.p.m. and delivering 50-cycle current at 3300 v. One set is from the English Electric Co., Limited, a second from James Howden & Co., Limited and the third from the British Thomson-Houston Co. For the Howden unit, the alternator was furnished by the General Electric Co., Limited.

General arrangement of the plant is shown in Fig. 1, boilers being at the right, turbines in the center and the substation at the left. The switchboard is at the rear of the turbine room. At the front, the station is open to Machinery Hall of the Palace of Engineering so that it is in full view of all visitors, with a broad gallery running along side the turbine room so that a good view can be had from above the machinery. Above the turbine room and substation runs a 10-T. electric crane with span of 47 ft. 6 in., furnished by Babcock and Wilcox, Limited, to be used in erection, repair and dismantling of the plant.

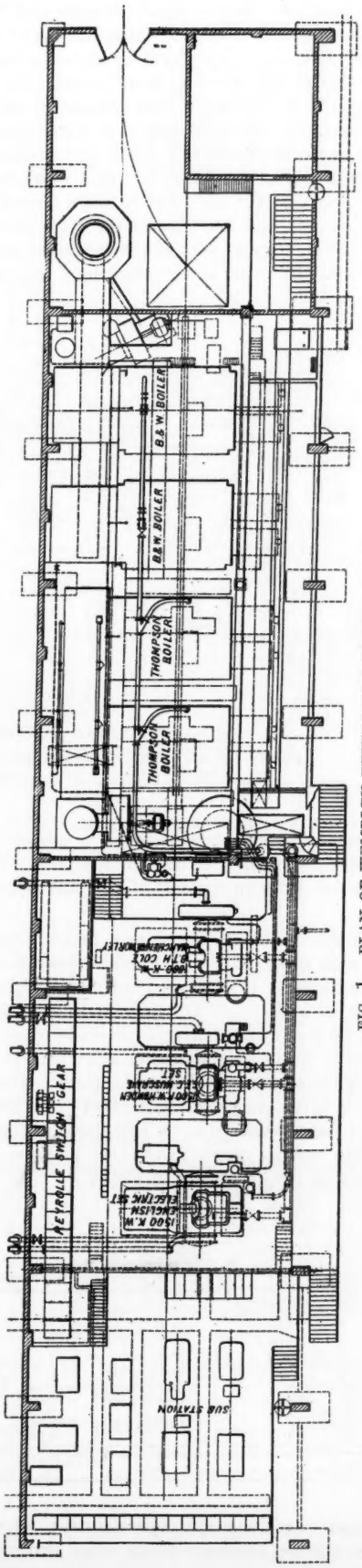
Boiler Plant

Steam is generated at 220 lb. pressure and superheated to 600 deg. F. Coal is burned on chain grate stokers and provision is made for measuring all coal and metering all water so that performance can be carefully watched. The intent has been to provide a plant well suited to meet the power requirements of the exhibition rather than to embody all the latest ideas in power plant practice but, at the same time, to include such equipment as would be justified in commercial plants of 5000 kw.

Babcock and Wilcox Installation

Two Babcock and Wilcox, land-type boilers are set separately, each boiler having 6182 sq. ft. heating surface and a maximum rated capacity of 25,000 lb. of steam an hour. Superheaters of bent tube type seen in Fig. 2 are situated between the tubes and the drums, while behind each boiler is a 96-pipe economizer, supplied by E. Green and Sons, Limited, having scraper gear designed to work at 220 lb. steam pressure. Babcock and Wilcox chain grates are used with epicyclic gear drive, each stoker being equipped with a Lea coal meter operated by the grate. Avery coal weighers will also register the weight of coal passing to each stoker.

One boiler is equipped by the makers with Diamond Valv-in-Head soot blowers, having six blower elements arranged to clean both boiler and superheater surfaces. Induced draft is provided, the gases passing downward through the economizers to a flue underneath, 7 ft. 9 in. high by 4 ft. wide, thence direct to the stack or through the induced draft fan, Fig. 3. The stack is self supporting, 6 ft. diam. by 75 ft. high. The 50-in. Sirocco fan is set at an angle with the flue a damper controlling the flow of the gases. The fan was supplied by Davidson and Co., Limited and the motor to drive it, which sets outside the fan casing, by the British Thomson-Houston Co. Coal is delivered to the stoker hoppers from overhead bunkers by means of circular chutes traversed from side to side of the


B.& W. BOILER
B.& W. BOILER
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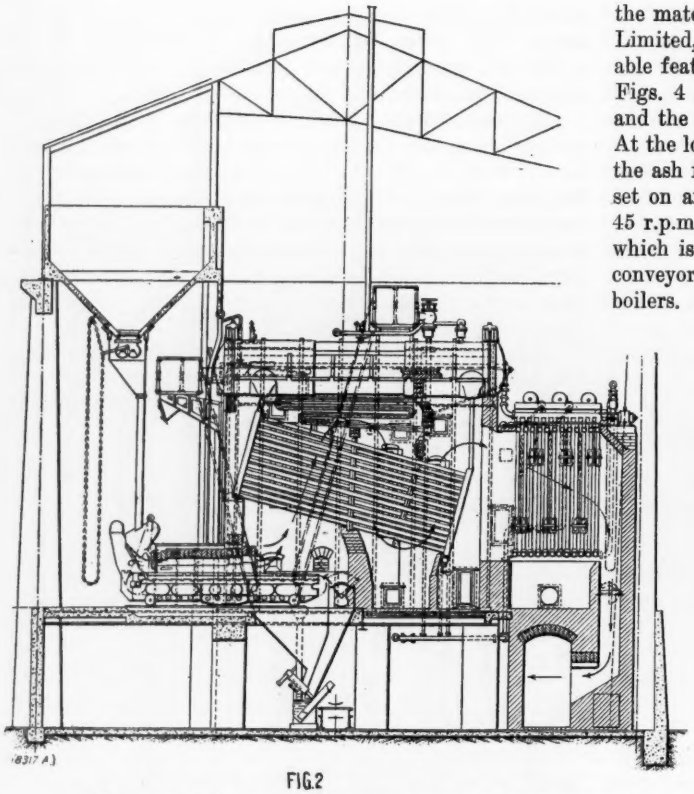


FIG. 2. BABCOCK AND WILCOX BOILERS HAVE ECONOMIZERS, SUPERHEATERS AND MECHANICAL COAL AND ASH HANDLING

the material handled. In this plant, Babcock and Wilcox, Limited, have installed a system which has many admirable features. The ash hopper has two chutes as shown in Figs. 4 and 5, one for the fines from beneath the grates and the other for the discharge from the end of the grate. At the lower end, the chutes are sealed by water into which the ash falls and from which it is lifted by a paddle wheel set on an incline as seen in Fig. 5. This wheel turns at 45 r.p.m., giving time for the water to drain from the ash, which is discharged over the edge of the tank onto a belt conveyor running lengthwise of the boiler plant under all boilers. The paddle wheel is supported by a long bearing

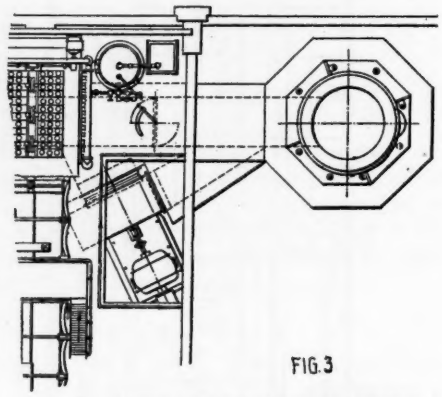


FIG. 3. GASES ARE REMOVED BY DIRECT DRAFT OR AN INDUCED DRAFT FAN

At the side of the boilers is a Kennicott water softening plant for handling 10,000 lb. of water an hour. The main tank is 10 ft. 6 in. high by 8 ft. diam. with capacity of 33,000 lb. of water, allowing 3 hr. for the passage of the water through the softener. Chemicals are proportioned to the amount of water entering the tank by means of a float device on the top of the tank, thorough mixing being secured by mechanical agitation. The mixture passes down through a central pipe, the clear water rising around the outside and the sludge settling to the bottom whence it is removed by opening the sludge valve once every 6 hr.

Ash Handling

Removal of clinker and ash is always a difficult problem on account of the cutting and corrosive properties of the material handled. In this plant, Babcock and Wilcox, Limited, have installed a system which has many admirable features. The ash hopper has two chutes as shown in Figs. 4 and 5, one for the fines from beneath the grates and the other for the discharge from the end of the grate. At the lower end, the chutes are sealed by water into which the ash falls and from which it is lifted by a paddle wheel set on an incline as seen in Fig. 5. This wheel turns at 45 r.p.m., giving time for the water to drain from the ash, which is discharged over the edge of the tank onto a belt conveyor running lengthwise of the boiler plant under all boilers. The paddle wheel is supported by a long bearing above the water, the weight being taken by a thrust washer so that it has no rubbing contact in the tank. Overflow water is carried away on the side of the tank opposite the conveyor.

The conveyor belt is 16 in. wide, of four-ply cotton impregnated with rubber and with a solid rubber face, 1/8 in. thick in the center. It is supported by troughing rollers, runs at 150 ft. a min. and is kept taut by a tension gear at the end farthest from delivery. Drive is by an electric motor through worm reduction gear and chain to a countershaft. The same motor drives the paddle wheels by a crank which gives reciprocating motion to a steel rope, operating a ratchet and pawl on each paddle wheel shaft. By throwing out its pawl, any wheel may be stopped. Arrangement of the drive is as in Fig. 6.

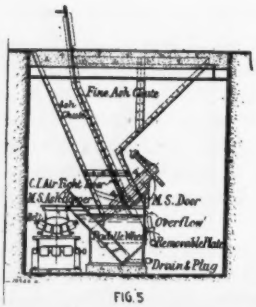


FIG. 5. DOUBLE ASH HOPPERS DISCHARGE UNDER WATER TO A TANK FROM WHICH A PADDLE WHEEL REMOVES THE ASH

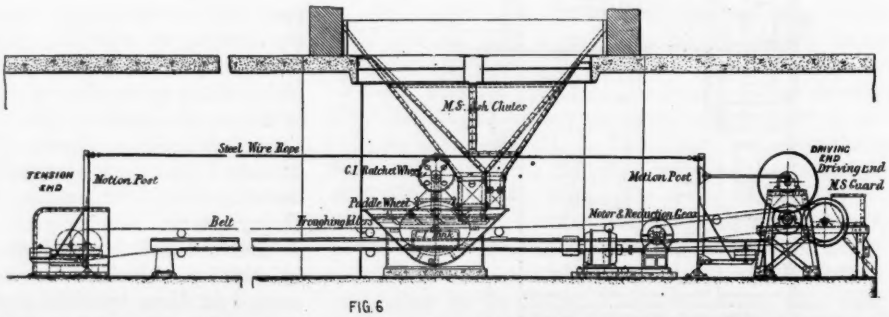


FIG. 6. BELT CONVEYOR AND ASH REMOVAL WHEELS ARE MOTOR DRIVEN THROUGH WORM GEAR AND CHAIN

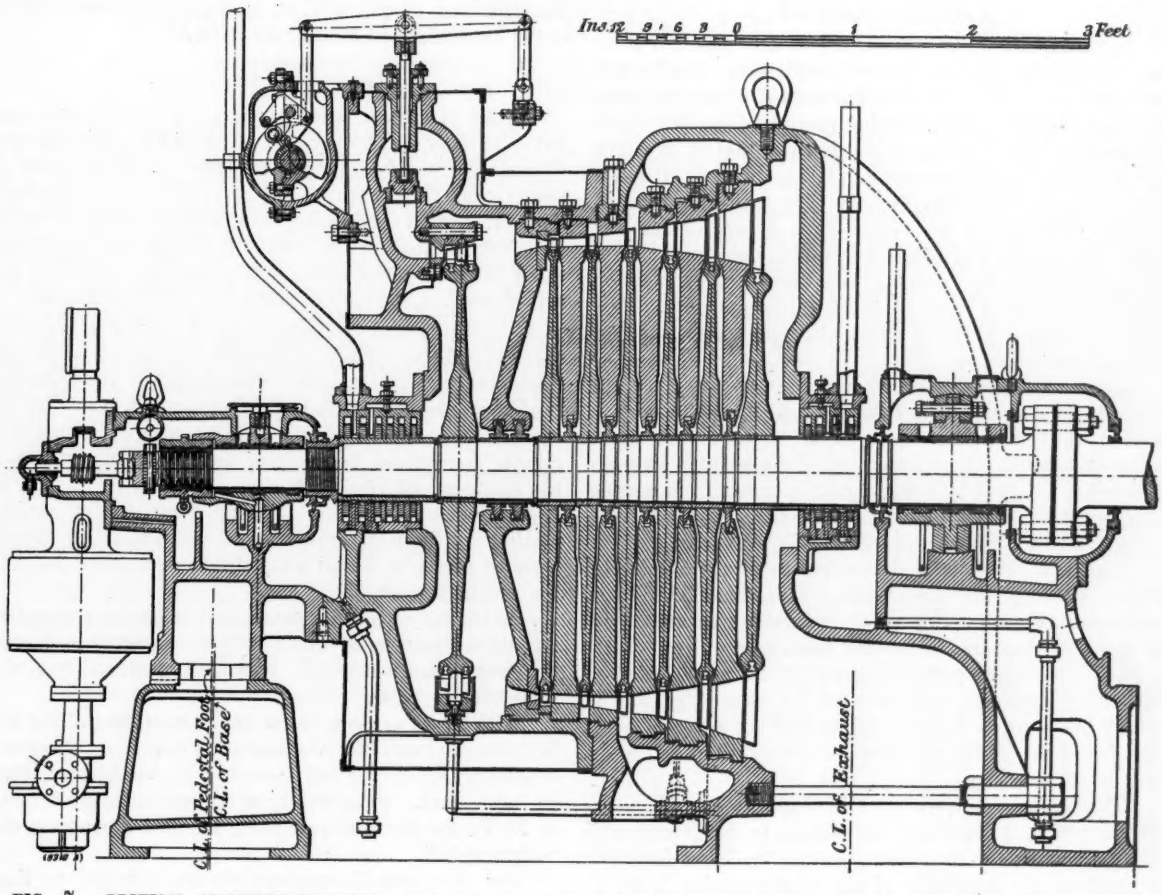


FIG. 7. BRITISH THOMSON-HOUSTON TURBINE IS SEVEN STAGE WITH BLEEDER PROVISION AT THE FOURTH STAGE

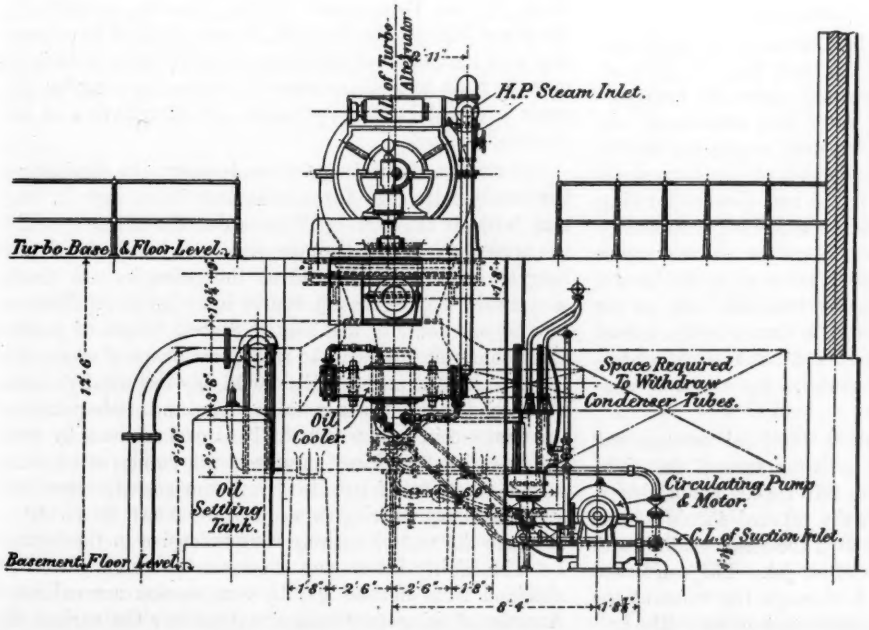


FIG. 8. CONDENSER IS SET CROSSWISE BELOW THE TURBINE WITH PUMPS AT THE RIGHT

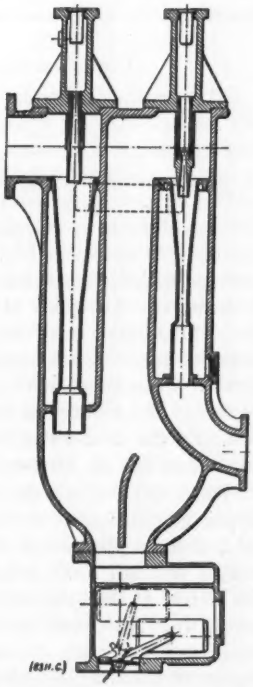


FIG. 9. AIR REMOVAL IS BY A DOUBLE JET DELAS EJECTOR

Turbine Equipment

As already stated, three units are installed, each of 1500 kw. capacity and having its own condenser. Details are now given only of the British Thomson-Houston Co. unit, which is fitted with a condensing plant by Cole, Marchant and Morley. The turbine takes steam at 200 lb. pressure and 600 deg. F. and exhausts into 28 in. vacuum. It has a first wheel of compound velocity type with two rows of buckets, followed by six single stage wheels of impulse type. All nozzles and blades are of stainless steel, control being by varying the number of admission nozzles in action through cams on a shaft operated by the governor. Provision is made to bleed off steam after the fourth stage for heating feed water but it is not in use.

Thrust is taken by a collar and groove bearing seen at the left end of the shaft in Fig. 7. The collars and grooves on the shaft fit into a white metal lining of the sleeve which is screwed into an extension of the bearing, its position being adjusted by a worm gear operated from outside the pedestal. In this way the axial position of the turbine rotor can be controlled while the turbine is running.

Glands at the ends of the casing are of the usual split carbon packing and garter-spring type, having a steam seal outside the outer ring which maintains pressure slightly above atmospheric to prevent in-leakage of air. Bearings have spherical, self-alining seats and are lubricated by oil under pressure, supplemented by ring oilers. The rotary oil pump is on the lower end of the governor shaft and forces the oil through a water-cooled oil cooler on the way to the bearings.

The shaft is stepped down in diameter from the low-pressure end, permitting the wheels to be forced onto bronze bushings by hydraulic pressure, the heavy forced fit preventing any possibility of the wheels coming loose.

Diaphragms between the wheels are castings, made in halves, tongued and grooved at the horizontal division and also on the outside where they meet the casing and secured against rotation by set screws.

Condenser and Accessories

Set crosswise of the turbine foundation is the condenser with its auxiliary apparatus at one end, Fig. 8. It is of standard design, with brass tubes and plates and contracting steam passages. Cooling water and condensate are handled by centrifugal pumps, driven by a common motor. Removal of air is by a Delas ejector which has some novel features. As shown in Fig. 9, it has two ejectors working in series, with ejector tubes water jacketed to give stability of operation. Air enters at the inlet on the left and steam through the nozzle at the top, the mixture being discharged through the divergent nozzle below into the body of the ejector. From this chamber, the air is drawn by the second ejector at the right and discharged at atmospheric pressure into the feed-water heater where the steam is condensed and the air liberated.

Water for cooling the tubes is admitted through the tapped connection at the right, passes around the right tube, then to the jacket of the left tube. From this it escapes through small holes in the tapered shoulder near the bottom of the tube, mixing with the steam and air and condensing the steam from the first jet. The condensed steam and water are drawn off, through the valve at the bottom of the chamber, by the condensate pump. The bottom opening is sealed by a float valve on account of the difference between the pressures in the condenser and in this chamber. In this way, all the heat is reclaimed, either in the condensate or in the feed water.

Generator Details

Design of the generator provides for a continuous output of 1875 kv.a. at 80 per cent power factor. Three-phase, 50-cycle current is delivered at 3300 v. and at speed of 3000 r.p.m. The machine will carry 25 per cent overload for 2 hr. without overheating, and permanent voltage variation from no load to full load will be not over 1 per cent at 80 per cent power factor and momentary variation not over 5 per cent, the control being by a Tirrill regulator.

Ventilation and cooling are by the closed air system, the cooler being placed along side the condenser in the foundations of the turbine. This cooler is like a surface condenser, the cooling water passing through the tubes and the air around the outside. About 85 gal. of water a minute is required, taken from the circulating system of the condenser at 75 deg. F. and a head of 10 ft. Hand-operated dampers permit of using fresh air for cooling, cutting out the water cooler, and an automatic thermostat gives an alarm, if the air temperature rises above the limit for which it is set.

On the end of the alternator shaft is carried a completely enclosed exciter, of which only the working surface of the commutator is exposed. It is of shunt wound type with commutating poles.

With 28-in. vacuum, the steam consumption of the unit is guaranteed at 13 lb. of steam per kw.-hr. for 25 per cent overload, 13.1 lb. for full load, 13.6 lb. for ¾ load, 14.62 lb. for ½ load. Total weight of the turbine and alternator is 28 T., the heaviest part to be handled during erection weighing 7 T.

For data and illustrations we are indebted to Engineering of London, Eng.

"The Story of Gasoline" is the title of a new three-reel industrial motion picture film just released for public exhibition by the Department of the Interior, through the Bureau of Mines. The film, which was prepared in cooperation with the Standard Oil Company of Indiana, is designed to make plain to gasoline users the numerous complex processes involved in the production and distribution of this essential product.

In a series of striking pictures is shown the obtaining of the crude petroleum from wells and its storage in huge tank farms in the vicinity of the wells. The means by which the crude oil is forced through pipe lines hundreds of miles long to other tanks located at the refineries are vividly portrayed. Approximately 60,000 mi. of such pipelines are now in operation in the United States. Views of modern petroleum refining plants in full operation are given, and by use of animated photography the highly technical processes by which the gasoline is extracted from the crude petroleum are depicted in minute detail. The novel methods by which the so-called "cracking" processes are employed to obtain larger fractions of gasoline from the gas oils remaining after ordinary refining procedure are shown so vividly as to make the matter entirely comprehensive to the layman.

The highly interesting processes by which gasoline is obtained from natural gas by compression are exhibited. A series of laboratory scenes makes clear the various distillation tests by which the gasoline produced is made to conform to governmental specifications.

Power Station Practice and Progress

PRESIDENT PATCHELL OF INSTITUTE OF MECHANICAL ENGINEERS COMPARES BRITISH AND AMERICAN POWER PLANT PRACTICE

WHEN W. H. Patchell delivered his presidential address before the Institution of Mechanical Engineers, he said much with respect to the problems before electricity supply undertakings. A particular feature of his lecture is the co-operation which has been secured from a number of British and American steam power stations with an annual output of over 30,000,000 kw.-hr. There appears no question, both from the units of electricity sold and the rate at which new plants are being added, that America is progressing far ahead of Great Britain. It seems that whereas the units sold per annum per head of population amount to about 100 to 300 units for Britain, the corresponding figure for the States is 500 to 700 units. Again to show the rate at which the maximum demand is increasing a table has been prepared from two sets of curves embracing respectively 6 British and 8 American stations representing electricity undertakings.

TABLE I. GROWTH OF MAXIMUM DEMAND

	British (6 stations)		American (8 stations)	
	Manchester Maximum Rate	Leeds Minimum Rate	Chicago Maximum Rate	Cincinnati Minimum Rate
1905	20,000 kw.	6,000 kw.	55,000 kw.	
1910	33,000	9,000	180,000	18,000 kw.
1915	52,000	14,000	335,000	27,000
1920	82,000	30,000	480,000	65,000
1923	95,000	33,000	620,000	105,000

Mr. Patchell's opinion based on practical observations on both sides of the Atlantic prompts him to suggest that the progress in the States is not due to any special engineering achievements but is the direct outcome of the skill and zeal of those who handle the sales department of the electricity supply undertaking. Apart from the electrification of industry, which on its intrinsic merits has been doing service to society and humanity, there must be developed the domestic electrification of the home. It is a means of filling up the "valleys" in the residence load curves.

To show the improvement in the thermal efficiency, Table II has been prepared showing the relative position of American and British practice. Highest thermal efficiency may not always mean lowest fuel consumption, because it is a matter of commercial as well as thermal economy. It pays under certain conditions to burn a larger quantity of low-grade fuel than a lesser quantity of high-grade fuel and sometimes vice versa. Thermal units cannot be obtained out of freight or costs of handling.

As a general rule, the best method of stating steam power station economy is to give the B.t.u. in coal per kw.-hr. sent out of the power station, as it is a good criterion of both the design and operation of the station.

Mr. Patchell sums up the position of thermal efficiency by the statement that with the best of apparatus design, and material now available, not more than 1 kw.-hr. can be produced on paper out of 1 lb. of best Welsh coal. How near it is possible to approach this ideal figure depends on the load factor and the handling of the plant (particularly in the boiler room), more so than on the design.

With reference to the use of higher boiler pressures, the question of maintenance will be important in addition to the material. The material of high-pressure boilers is by no means settled, although mild steel appears to be preferred in place of nickel steel. The alternative to using huge masses of material to meet these new pressures and temperatures is either to use alloy steel or introduce radical alterations in the design of steam generators. It has been found that a mild steel containing, say, 0.14 per cent carbon will at 752 deg. F. if tested, break in 1 hr. at a stress from 25 to 30 T. per sq. in. If, however, this steel is tested at a temperature of 752 deg. F., so as to determine

TABLE II. COMPARISON OF BRITISH AND AMERICAN POWER PLANTS

	Millions of Units d/d to Mains.	Load Factor (on 30-minute Max. Load).	B.Th.U. per Kw.-hr. d/d.	Thermal Efficiency per cent. (on Units d/d).	Units Sold. Total in Millions.	Units Sold. Per Head of Population.
Glasgow Corporation	183·20	27·6	20,130	16·94	200·00*	103*
Dalmarnock	—	—	—	—	—	—
Newcastle E.S. Company	234·27	48·5	20,720	16·47	—	—
Carville B.	—	—	—	—	—	—
Newcastle E.S. Company	97·93	34·4	21,130	16·15	—	—
North Tees	—	—	—	—	—	—
Clyde Valley E.P. Company	69·36	44·0†	21,810	15·65	—	—
Clyde's Mill	—	—	—	—	—	—
Lancs. E.P. Company	101·20	31·0	21,930	15·54	—	—
Radcliffe	—	—	—	—	29·95	120
Stepney Boro., London	44·33	27·3	22,350	15·27	—	—
Narrow Street	—	—	—	—	—	—
Newcastle E.S. Company	128·90	24·9	22,850	14·94	—	—
Dunston	—	—	—	—	18·56	94
Hackney Boro., London (M.)	20·38	20·6	23,100	14·78	—	—
Mare Street	—	—	—	—	—	—
Central E.S. Company, London	55·69	21·7	23,400	14·58	—	—
Grove Road	—	—	—	—	—	—
L.M. and S. Railway Company	53·48	66·3	22,640*	14·44*	—	—
Stonebridge Park, London	—	—	—	—	—	—
Clyde Valley E.P. Company	49·53	23·6	24,050	14·19	—	—
Yoker	—	—	—	—	—	—
Southern Railway Company	49·17	43·5	24,400	13·99	—	—
Durnsford Road, London	—	—	—	—	30·92	220
Bolton Corporation	46·76	27·6	24,870	13·73	—	—
Back o' th' Bank	—	—	—	—	65·77	236
Bradford Corporation	76·39	27·5	25,010	13·65	—	—
Valley Road	—	—	—	—	42·98	417
Rotherham Corporation	53·64	26·5	25,050	13·62	—	—
Rawmarsh	—	—	—	—	185·24	218
Manchester Corporation (M.)	200·94	29·9‡	25,140	13·57	—	—
Stuart Street	—	—	—	—	—	—
N. Metropolitan E.P.S. Company	31·00	26·0	25,840	13·21	—	—
Brimsdown	—	—	—	—	—	—
N. Metropolitan E.P.S. Company	45·51	29·8	25,980	13·14	—	—
Willesden	—	—	—	—	—	—
Milwaukee, Wis.	313·84	45·3	18,030	16·92	—	—
Lakeside	—	—	—	—	1,159·80	715
Detroit, Mich.	147·93	47·3	18,923	16·03	—	—
Marysville	—	—	—	—	2,966·26	735
Chicago, Ill.	517·71	40·8	19,215	17·76	—	—
Calumet	—	—	—	—	235·55	647*
Cincinnati, Ohio	410·48	43·8	19,490	17·51	—	—
West End	—	—	—	—	999·65	500*
Philadelphia, Pa.	468·35	42·8	19,800	17·41	—	—
Delaware	—	—	—	—	1,052·93	604*
Duquesne Light Company, Pa.	594·06	61·8	19,510	17·49	—	—
Colfax	—	—	—	—	—	—
Detroit, Mich.	695·87	49·9	19,666	17·35	—	—
Connors Creek	—	—	—	—	—	—
Philadelphia, Pa.	278·66	52·2	19,930	17·13	—	—
Chester	—	—	—	—	876·68	337
Newark, N.J.	498·73	45·5	20,030	16·30	—	—
Essex	—	—	—	—	379·88	301
Boston, Mass.	482·33	39·0*	21,520	15·86	—	—
L Street	—	—	—	—	700·71	700*
Cleveland, Ohio	775·06	47·7	21,880	15·60	—	—
Lake Shore	—	—	—	—	—	—
Chicago, Ill.	813·10	55·5	21,990	15·54	—	—
North West	—	—	—	—	679·68	350
Baltimore, Md.	390·05	39·7‡	23,450	14·55	—	—
Westport	—	—	—	—	165·95	—
Hartford, Conn.	99·44	33·4	23,750*	14·39*	—	—
Chicago, Ill.	—	—	—	—	—	—
Fisk Street	399·34	46·6	24,080	14·20	—	—
Detroit, Mich.	—	—	—	—	—	—
Delray	502·55	53·8	24,464	13·95	—	—
Interborough R.T. Company, New York	—	—	—	—	—	—
74th-street	496·30	40·7	24,750	13·79	—	—
Brooklyn, N.Y.	—	—	—	—	443·00	214
66th-street	215·97	41·1	25,980	13·13	—	—

(M.) Indicates that the figures are for the year ending March 31, 1923; the remaining figures are for the year ending December 31, 1923.

* Indicates approximate figures only. † Indicates 15-minute maximum load. ‡ Indicates 60-minute maximum load.

the stress at which there is no continuous change of form (i. e., a small increment of stress will produce fracture in a long time) then the critical stress is only about 14 T. per sq. in. If the working stress in a tube, for instance, is 5 T. per sq. in., the factor of safety is less than 3. Furthermore if the temperature is raised to 932 deg. F., the critical stress is only about 4 T. per sq. in. It indicates, therefore, that as long as temperatures do not exceed 750 deg. F., there is ample factor of safety, but with temperatures approaching 930 deg. F. the factor of safety is small, unless the working stress is small. Merely increasing the carbon content of the steel to, say, 0.32 per cent carbon does not increase the critical stresses greatly at 750 or 930 deg. F., as these are raised only to 16 T. and 6 T. per sq. in. respectively.

Certain alloys, however, containing large percentages of nickel have critical stresses at 930 deg. F. as high as 16 T. per sq. in. The same alloy steel when tested so as to

break in 10 hr. fractured at a final stress of 32 T. per sq. in.

A specimen of steel containing 0.35 per cent carbon, 1.0 per cent chromium and 1¼ per cent nickel tested at 977 deg. F. carried a stress of 25 T. per sq. in. before breaking in 4 hr. The same steel, however, when tested at the same temperature broke at 7 T. per sq. in. in 1060 hr. The critical stress for this steel at 977 deg. F. is about 6 T. per sq. in.

It seems, therefore, that the most important point in connection with boiler work is to keep the temperature below, say, 875 deg. F. to ensure a safety factor of 2.

The rate at which boiler design and turbine output has progressed is almost phenomenal, and the problems which face engineers today in the light of modern advancement and development embrace designs for boilers of 400 lb.

TABLE III. DEVELOPMENT OF POWER PLANT UNITS

Year	Boiler Pressure lb. p. sq. in.	Heating Surface sq. ft.	Kw. per unit	Steam, lb. p. kw. hr.
1879	80	60	.....	...
1881	...	.....	16	140
1891	150	1,800	.....	...
1893	...	.....	100	31
1896	...	3,600	250	...
1898	...	.....	750	22.8
1901	160	8,100	1,600	18.4
1903	...	21,700	4,000	18.0
1906	...	.....	6,000	17.7
1909	200	23,500	15,000	13.7
1915	...	.....	20,000	11.3
1918	...	.....	45,000	10.9
1920	240	26,500	.....	...
1921	350	29.800	.....	...
1923	...	30,600	.....	...
1924	400	.....	.....	...

working pressure and 30,000 sq. ft. heating surface, and single barrel turbines of 50,000 kw. capacity. This is present-day power plant engineering grown up from the small beginning of little more than 40 yr. ago as summarized in Table III.

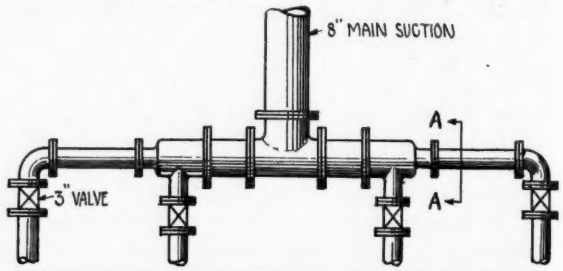
Changes in Suction and Liquid Headers Promote Safety

By A. G. Solomon

IN A large refrigerating plant there were several brine tanks used for cooling the brine which was circulated through the coils and sprays of cold storage rooms and coolers. The tanks were about 20 ft. square and nearly as deep. The coils in the tank were closely spaced in order to produce maximum capacity.

These tanks were old and it would be a question of only another year or two until they would have to be replaced. The foundations under the tanks were of the usual concrete with cork insulation between the concrete and the bottom of the tanks. Trouble first developed, due to the breaking of the suction line at a flange near one of the tanks. This was repaired and the tank put in service again.

It was then noticed that the horizontal run of the suction line did not look straight and in line. As there were no leaks, little attention was paid to looks. In a short time the tank top was noticed to be humped up in the center. Since the top was supported on the coil hangers which rested on the bottom of the tank, it was at once seen that the foundation had cracked and ice (caused by the low temperature of the brine) was lifting the tank. This put a dangerous strain on the liquid and suction lines. The coils were in four sections so there were four 3-in. suction lines from each top header and four 1-in. expansion lines from the main liquid line to the bottom headers.



ORIGINAL LAYOUT WITH STRAIGHT DROPS TO TOP HEADERS OF COILS
FIG. 1

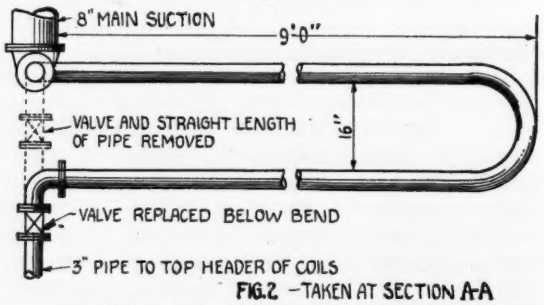


FIG. 2 —TAKEN AT SECTION A-A

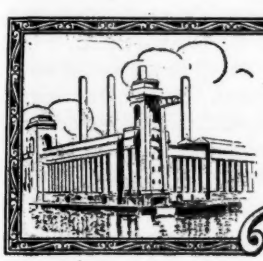
FIG. 1. ORIGINALLY THE HEADER WAS CONNECTED TO THE COILS BY STRAIGHT PIPES

FIG. 2. FLEXIBLE U BENDS WHICH WERE SUBSTITUTED FOR THE STRAIGHT DROPS

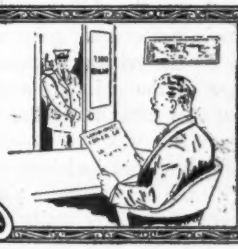
After some discussion, it was decided that the pipe work was under such a strain as to be dangerous, therefore the tank was cut out of service and the liquid and suction lines were disconnected from the main lines. To do a permanent job would mean lifting or moving the tank and putting in a new foundation. It was estimated, however, that the old tank would not hold together if disturbed. The weight of the coils would push the bottom out and if the coils were removed much valuable time would be lost. The question was to do something quickly and keep the tank in service for a few more years.

It was finally decided that flexible pipe connections between the coils and the main lines would be the proper solution; accordingly long U bends were made and the tank connected up and put back in service.

This tank moves up and down so that at times it is often out of level as much as 3 in. No doubt there is some strain on the coils but there is no strain on any of the pipe work above the brine. If a coil should break, there would be a loss of some ammonia but there would not be the danger to life that there would be if one of the main lines broke. Two hangers were used on each bend, one close to the header end and one near the bend. This left the bottom part of the U bend free to move up or down. The four expansion lines to the coils were made just like the suction bends only 1-in. pipe was used. One end of each 1-in. bend was connected to the liquid header and the other end to the expansion valve. The hangers were the same as used for the 3-in. bends.



LETTERS DIRECT FROM THE PLANT



Chimney Lightning Rod Replaced in Novel Way

THERE ARE, I am told, more ways than one to skin a cat, or, which is more to the point, to climb a stack. This was brought forcibly to my attention a short time ago when we found it necessary to replace the lightning rod on one of our stacks. The rod that had been put up when the stack was erected had corroded to such an extent that it had practically parted company at a number of points and was therefore entirely inadequate to carry any very heavy lightning discharge. This condition constituted, of course, a serious hazard, one to be remedied at the first opportunity with but little regard for cost.

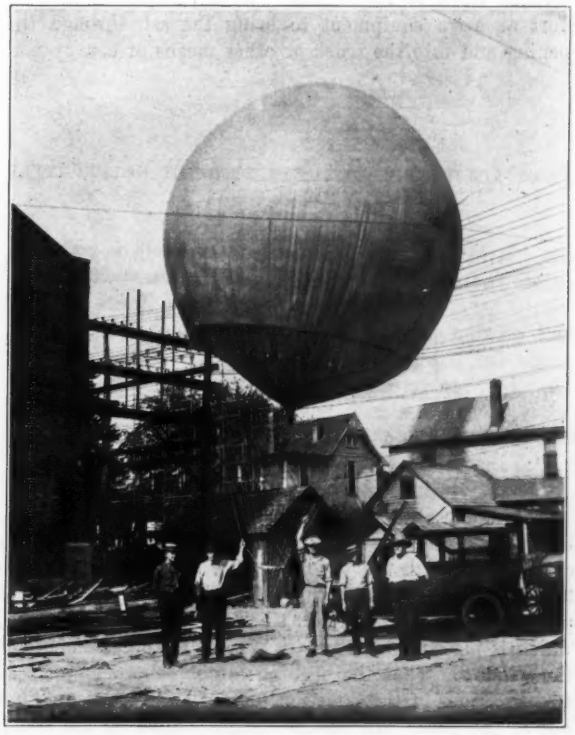
The stack is of reinforced concrete construction, 10 ft. inside diameter at the top and 225 ft. high, and is not provided with a ladder for the reason that it was thought that the rounds would become corroded to such an extent in a comparatively short time as to be unsafe for workmen, the reasoning behind this conclusion being that no ladder would be required until the lightning rod needed replacing and when that time came the latter would also be in such condition as to require replacement.

When it came time, then, to replace the lightning rod, we found ourselves in a quandary as to how to go about it. The problem resolved itself naturally into the question of how to get to the top; after that everything would be easy. We soon gave up the idea of doing it ourselves and accordingly called in a steeplejack to see what he could do. He tried the usual method of passing slings around the structure and hoisting them, one above the other a few inches at a time. Owing to the size of the stack, however, this method proved to be impractical and had to be abandoned. During the course of the next few weeks several other steeplejacks were invited to have a try at it but they all failed until the last man got on the job.

He went at it in a manner similar to that employed by his predecessors and was furnishing amusement to a number of the day shift who could get away from their jobs for a few moments. While we were all kidding him along and giving him the usual line of bystander's advice, an aeroplane from the nearby aviation field hove in sight and circled over us. The occurrence inspired some bright light to suggest that he take a hook up in a plane and drop it over the wall of the stack as it flew past. The remark was greeted with appropriate laughter by everyone except Mr. Steeplejack, who grew serious and looked as if he had caught on to something.

He left shortly afterwards and did not return the next day nor the next, and we had begun to think he had given up in disgust. But not so; he showed up the next morning with a broad smile on his face and a mysterious looking bundle in his car. He wore that peculiar look that proclaimed him in the know, but he would tell us nothing; we were all on the outside looking in.

He laid his bundle out on the ground and beside it a cylinder of hydrogen. On opening the bundle he disclosed what looked like a rod of oiled silk wrapped round with a maze of cording. This he unwrapped and spread out on a tarpaulin that had been hastily stretched over the ground. Then he applied a tube from the hydrogen tank to what appeared to be a loose end of his cloth and turned on the



BALLOON READY FOR ASCENSION

gas. The folds of the cloth began to bulge out and we began to get an inkling of what was going on. The bulge gradually increased in size until the thing began to resemble a huge bag. Such it was; a balloon, as I live. Soon the thing exhibited a tendency to rise and we tied the end of the cording to a convenient sand bag. Shortly after the balloon was completely filled and straining at its mooring, at which time the accompanying picture was taken.

A hook to fit over the edge of the chimney was then attached to the cording by means of a latch release. To the hook was attached a block carrying a light line. Three guide lines were then attached to the hoop to which the cording was rigged and balloon was allowed to rise. One of these lines was given to each of three men who stationed themselves in a triangle about the chimney. By careful giving and taking in on these lines, the balloon was cen-

tered over the chimney, about 50 ft. above as, the chimney was in use and hot gases were being discharged.

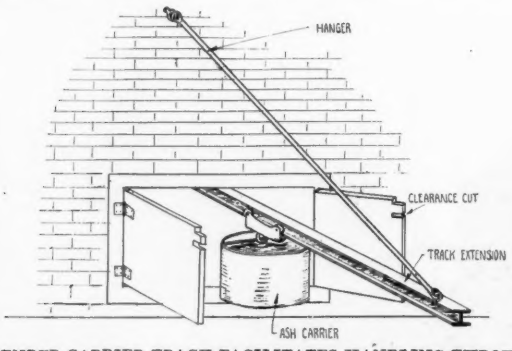
At the critical moment, the hook was lowered over the edge of the chimney and the latch sprung. Everything was easy after that; the balloon was brought down and a heavy line was run through the blocking by means of the light line that had been run through before the ascension. With the heavy line in place, a man was hauled up and the necessary repairs easily made.

We had been told that this thing could not be done, but by getting away from usual methods it was accomplished.

Kokomo, Ind. L. C. FITZSIMMONS.

Handling the Ash Carrier Through the Window

IN MANY ash handling devices, the carrier is run on an overhead track to the nearest opening, requiring manual effort or extra equipment to bring the ash through the opening and into the truck or other means of conveyance.



EXTENDED CARRIER TRACK FACILITATES HANDLING THROUGH SMALL OPENINGS

As a departure from these means, a recent installation of a carrier system was made with the carrier track extended through the window of the basement which contained the boiler. The arrangement is shown in the accompanying sketch. The carrier track consists of an "I" beam, which is placed centrally with respect to the casement for the window. That the opening might be properly closed small sections of the same outline as of the track were cut out of the door. An outside hanger supported the extension and the length was made sufficient to allow the loaded ash carrier to be dumped directly into the trucks.

Washington, D. C. G. A. LUERS.

Removing a Blowoff Valve Seat Under Difficulties

I HAVE a 2½-in. blowoff valve of the Y type on one of my boilers. A short time ago this valve started to leak badly. As the next day was cleaning day for this boiler, I decided to find out what was wrong with it. When it was taken apart, I found that the seat, which was of the renewable type, was cut badly. To remove the seat, it is necessary to place a piece of flat or square iron between the two lugs A and B, then using a monkey or pipe wrench on the iron to turn the seat out of the valve body. In trying to get the seat loose, I found that much force had to be used and broke off both the lugs A and B without dislodging the seat.

As there was not time to disconnect the valve from the boiler to have the seat cut out at the machine shop, I hit upon the idea of making a tool as shown in the accompanying sketch for removing the valve seat. The tool is made a little taper at one end and the edges of the tool were made as shown at C. This tool was then driven into the opening of the seat until the edges were firmly set into the sides of

TOOL USED TO REMOVE VALVE SEAT

the seat. Then by using a 36-in. pipe wrench on the tool, the seat was removed without any further trouble.

Milwaukee, Wis. H. A. JAHNKE.

Function of the Air Chamber

THERE IS one point in power plant operation which has received little if any attention from the average writer and that is the quantity of air in the air chamber on steam pumps. It may be news to some to learn that it is not unusual for new employes with but little experience to get the impression that the function of the air chamber is to promote smooth operation by removing air from the water and it may be a long time before they realize that the business of the air chamber is to collect and hold air which will act as a cushion or shock absorber, preventing pounding which would occur if each stroke of the pump was forcing the water against a solidly resisting surface.

Some men with considerable experience, get altogether wrong ideas about the air chamber. One such man asked me how often I let the foul air out of the reservoir. I told him the trouble was not in getting the air out but in keeping enough in. This man said that he thought there would be enough air escaping from the water to keep the chambers full. This could happen but it seldom does. Few air chambers, if left as they are sent from the factory, will perform their full duties, as ordinarily no provision is made for removing the water and refilling with air, without draining the pump. A partially filled air chamber may prevent serious jarring but the properly filled one will be a big help towards securing a smooth running machine.

A properly operating pump means less repairs to valves, studs and springs. Sometimes seemingly unaccountable accidents to these articles are directly due to the fact that the air chamber is completely filled with water. A leaking air cock on top of the chamber is often the reason the chamber is made useless. By having a small valve on top and at the bottom of the chamber it can be emptied of water and filled with air in a few minutes at any time without draining the pump, although it will be necessary to shut down the pump while doing so.

How often have you seen water gage glasses on even large steam pump air chambers? In my experience it has been the exception rather than the rule. When such glasses are used they should be placed not lower than the middle and extend to the top, for it is seldom the compressed air in the chamber will occupy more than half of the space under normal working conditions. I have seen pump air chambers elaborately fitted up with globe and check valves

for the purpose of keeping the air chambers filled with air without shutting down the pump. In my opinion such equipment is unnecessary unless the pump is one that can not be shut down for a few minutes now and again to remove the water from the chamber and to replace it with air.

JAMES ELLETHORN.

Ghosts in the Boiler

SOME YEARS AGO in an old saw mill there were two boilers of the horizontal return tubular type, equipped with steam domes. The engineer sent for me one day, saying he had a mystery. When I arrived at his plant, he told me to wait awhile and I would hear it. I did not have long to wait; soon there was a loud crack which sounded something like a partially muffled pistol report. We searched all over the place but could find nothing amiss anywhere. Anon, we heard another report.

We were on top of one of the boilers at the time and the sound seemed to come from the other boiler somewhere. Accordingly we crossed over to the second unit and waited. Presently we were rewarded with another "crack." The domes were well covered with insulating material and I was standing with my hand on top of it at the time. It felt as though someone had hit the palm of my hand a light blow with a hammer. The covering was immediately removed and we found that the top of the dome was breathing; first it would bulge out and then bulge in and at each change there was a loud report like we used to hear when mother put her dish pan on the hot kitchen stove.

After cooling down the boiler, we opened it for inspection and found that every brace in the dome was broken. This defect was not remedied, as several other things were found to be wrong. Instead, a second-hand boiler was bought and erected as cheaply as possible to finish up the work in that location. When the mill was moved to a new site, some time later, new boilers were bought and installed.

Minneapolis, Minn. FRED S. RUTLEDGE.

The Appreciation of Firemen

ON PAGE 381 of the April 1 issue in an article by Jack L. Ball, "Some Hints for Boiler Firemen," this statement appears: "It is a mistaken idea that a company does not appreciate a good fireman, although we often hear remarks to the contrary."

I shall illustrate the way in which one manufacturer appreciated a most excellent fireman and there are many more of the same stamp. The fireman made a saving in coal over the amount used by his predecessor that paid exactly one-half of his wages although the plant was small consequently there was not much chance to make a record. Not one dollar had been spent for any appliance by means of which coal could have been saved. There was no separator on the exhaust pipe of the engine and, as all of the condensate was used as feed water, the boiler was literally loaded with cylinder oil.

It became necessary to shut down for two days to clean the boiler and to allow the inspector to make a thorough inspection. A Sunday and the following Monday were utilized for this purpose and the plant was ready for service on Tuesday morning.

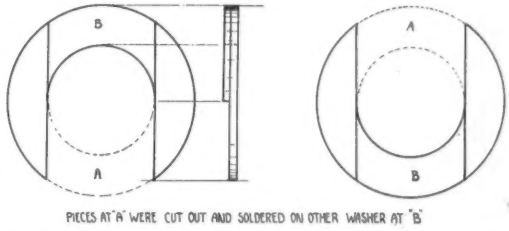
The fireman was informed that they did not pay for Sunday work, neither was the fireman, as a rule, paid for any time during which the engine was shut down, but as a special concession he would be paid for one-half day on Monday, therefore for 7 long days that week he was paid for 5½ days.

New Haven, Conn. W. H. WAKEMAN.

Remedy for Leaking Pump Packing

MY VACUUM pump had to be repacked about every two weeks and after trying all the different packing on the market with no success, I took out the piston rod and found that the rod had about ¼-in. clearance between it and the stuffing-box.

Upon investigating I was informed that the engineer before my time had had the rod turned down and a new



SPLIT COLLAR TO ADAPT OVERSIZE STUFFING-BOX TO THE ROD

stuffing-box gland made to fit the rod but did not alter the stuffing-box. Therefore, the packing worked its way into the steam chamber.

To remedy this I made two washers, the outside diameter to fit the stuffing-box and the inside, I cut enough of each washer to allow it to slide over the rod. The piece that was cut out was soldered onto the other washer.

These two pieces dovetailed together after having been slipped over the rod and formed an effective back stop in the stuffing-box. After they were installed we had no further trouble.

Milwaukee, Wis. WM. C. FUNK.

Fireman's Capacity for Usefulness

ERNEST E. CLARK'S letter, "Doing Away with Licensed Firemen and Engineers," on page 449 of the April 15 issue, brings to my mind the question of what is expected of an operating engineer or fireman. I have burned as high as 20 lb. of coal per sq. ft. of grate surface per hour with a CO_2 average of 13.5 per cent, cleaned the fire during the 12-hr. run, wheeled and weighed better than 3 T. of coal, cleaned the ash pit and have then been accused of being downright lazy for sitting down between firing periods.

Firing is all work, requires considerable skill to maintain good combustion and a lot of patience if the load is to be followed with any degree of accuracy.

Few people have a good understanding of an engineer's ability or what he actually accomplishes in a day's work, consequently the work is made light of.

This belief on the part of the public and frequently on the part of the employer seems to be chronic and it is up to the engineer to make himself better known and his importance thoroughly understood.

Since there is no standard of wages for engineers and firemen, they will continue to wrangle with the employer on wages and the working capacity of the men about the plant.

As this department of a manufacturing plant is carried on the books as "maintenance" and since this branch of service is a necessary evil, and thought of as such, it consequently becomes something that must be run as cheaply as possible, in order to keep production costs at a minimum.

The inefficiency of burning coal in hand fired settings with cheap labor and all that goes with cheap labor in the form of ignorance and neglect has contributed, especially in the case of the larger industrial plants, largely to the adoption of the mechanical stoker and to the apparently increasing use of central station energy for power in connection with low pressure boilers for heating purposes.

Worcester, Mass. LEROY BLAKE.

Federal License Law

REFERRING TO Ernest E. Clark's letter, on page 449 of the April 15 issue, in regard to the licensing of engineers and firemen, let me say that in my opinion there will always be trouble until some sort of a national law is put through covering the licensing of engineers and firemen for all classes of stationary plants for pressure over 1 lb.

We need a federal license law similar to the one to which marine engineers and firemen are subject.

Geneva, N. Y. R. G. SUMMERS.

Fine Pulverization Increases Combustion Efficiency

COMMENTING ON the article "Investigation of Powdered Coal," appearing in the April 1 issue, I believe that some of the conclusions which the author has drawn can be discussed further to advantage.

In the last paragraph of the article the statement is made that the larger particles of coal fall with greater velocity, rise with smaller velocity and rub against the surrounding gas at a greater rate than the smaller particles of the same density, and that this action causes the larger particles to burn more rapidly.

It is true that the greater the rapidity of travel of a particle of fuel through the air the more rapid its rate of combustion, for the reason that the gaseous products of its combustion are more quickly removed from its surface and the air allowed to come into closer contact with the burning fuel. It is impossible, however, to control the distribution of the air and gases in the furnace in any but a general way and it is as likely that the particles of fuel will travel through inert furnace gases or air contaminated with these gases as through pure air. Even should the particle of fuel travel through pure air, the increased rate of combustion of a large particle due to its more rapid travel would be offset by its smaller surface to volume ratio as compared to the larger surface to volume ratio of a smaller particle.

The rate of combustion of a body depends upon the extent of its surface that is exposed to contact with the air and since surface increases as the square while volume increases as the cube, it is evident that the greater the volume of a body the less in proportion will be the surface, therefore the less rapid will be its rate of combustion as compared with a smaller particle of the same density.

Distillation of powdered coal before ignition leaves the particles enveloped in combustible gas mixed with air and when ignition occurs the gas burns more rapidly than the particles of carbon, thus robbing them of air and leaving them surrounded by inert gases incapable of supporting combustion. The problem then is either to get these particles to the air or else to get air to these particles as quickly as possible so that their complete combustion will not be delayed.

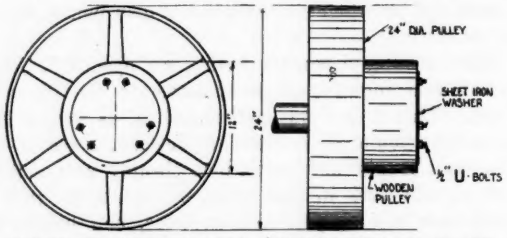
Now, the finer the particles the quicker are they ignited and the more rapid their combustion provided the requisite amount of air is present; also, the shorter the distance it will be necessary for them to travel in the air in order to complete their combustion. The speed of flame propagation depends as much upon the fineness of the particles as upon the ratio of coal to air.

It seems logical, therefore, to assume that the way to obtain maximum combustion efficiency lies in extremely fine pulverization and special attention to burner and furnace design.

Schenectady, N. Y. S. C. MARTIN.

Homemade Emergency Pulley

AT THE end of a line shaft was a 24-in. cast-iron pulley which took all the space on the shaft, in fact acted as a set collar also. It became necessary to add a 12-in. pulley, 6-in. face, to the end of that shaft. We resorted to the following scheme: Two pieces of 4 by 12-in. plank, were cut 1-ft. long and placed cross grain one over the other. Six $\frac{9}{16}$-in. holes were then bored through as indicated on the accompanying sketch. We made three "U" bolts of ½-in. iron to fit the spokes of the large pulley, a 10-in. diameter washer made of ⅛-in. iron sheet was drilled to



BLOCK PULLEY MOUNTED BEYOND END OF SHAFT

fit the holes and the whole fastened with the "U" bolts to the 24-in. pulley. This home made pulley was trued in place with a long handle wood chisel while running. The pulley was to drive a triplex pump and it was important to consider strength of first importance.

Pahrump, Nev. CHAS. LABBE.

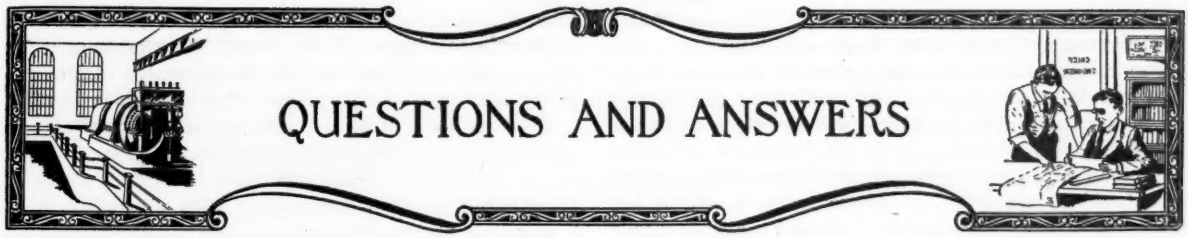
The Exhaust Went to Waste

THERE IS in our plant a 1500-gal. hot water general service tank which is heated by live steam admitted to the coil in the tank by a thermostatically controlled reducing valve and at the same time the exhaust from our boiler feed pump is allowed to go to waste. What was in the mind of the designer when he laid out the plant or why the arrangement was allowed to remain, I am unable to say. It seemed to me a quite unnecessary and uncalled for waste.

To correct the condition I simply connected the exhaust from my pump to the low pressure of the reducing valve and now the water is heated with exhaust steam. When there is a heavy demand for hot water or when the pump is not in operation just enough live steam is bled through the reducing valve to supply the required amount of heat.

Needless to say this exceedingly simple alteration in design resulted in a quite appreciable saving in fuel.

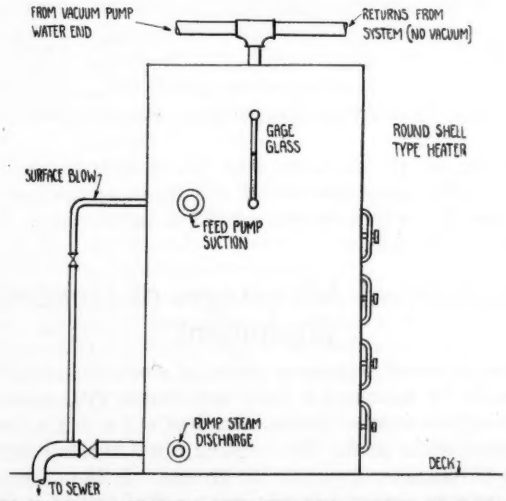
Des Moines, Ia. A. D. RALF.



Peculiar Heater System Will Not Function Under Back Pressure

I AM in charge of a vacuum heating system for which steam is supplied by boilers operating at 50 lb. gage pressure. Returns drain back to a small receiver tank from which the condensate is delivered by a vacuum pump to the heater. The exhaust from this pump is piped to the heater as is also that from the boiler feed pump. These two exhaust lines join and enter the heater at a point near the bottom of the shell.

With a boiler pressure of 25 lb. gage the vacuum pump will work satisfactorily, but there are times when the heater will be subjected to a back pressure of 5 or 6 lb. and under these conditions the pump will not work fast enough to keep the heater full. As the feed pump takes its suction from a point about half way up the side of the heater, obviously I have to keep the heater practically full all the time. The feed pump is in no way affected.



PUMP EXHAUST ENTERS THE HEATER BELOW THE WATER LEVEL

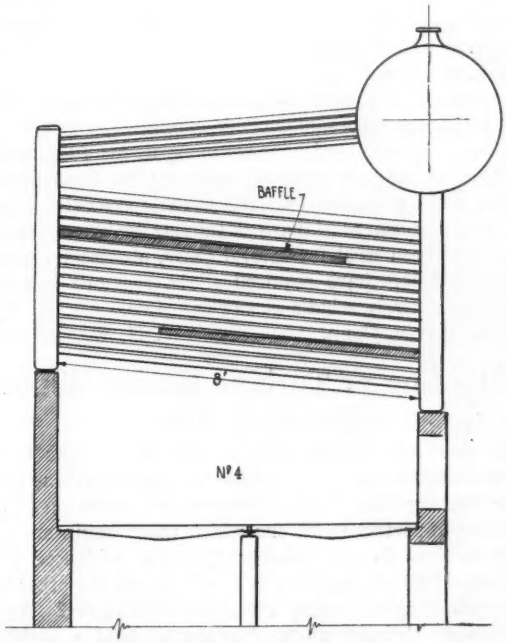
Can it be possible that the head of water over the pump exhaust would prevent this pump from exhausting? What might be done to correct this condition? The heater, shown in the accompanying sketch, is an old and peculiar one of which nobody seems to know the history.

R. G. S.

Would a Dutch Oven Help Efficiency?

I WOULD like to inquire if any of the readers of Power Plant Engineering have had any experience with the horizontal water-tube type of boiler such as was built for the U. S. Shipping Board during the war. They are of the cross drum type, as shown in the accompanying sketch. The tubes are 8 ft. long and are baffled horizontally. The grate surface is about 72 sq. ft. and the heating surface, 2581 sq. ft. The grate is set directly under the tubes and there is no combustion chamber, the bridge wall being the rear wall of the setting.

How would these boilers work with a dutch oven extension in front, using the space under the tubes as a combustion chamber? If these boilers are put in service,



B. & W. BOILER WHICH IT IS PROPOSED TO USE IN A DUTCH OVEN SETTING

the greater part of the fuel will be sawdust, straw, bark and excelsior dust. They will have to work right up to rating all the time and occasionally may have to develop as much as 150 per cent rating.

If a dutch oven were built and the scrap fuel fed through the top, would 7 ft. from the grate to the arch be sufficient? This would give a furnace volume of 7 by 7 by 11 ft., or 539 cu. ft. Could the proposed load be carried with natural draft or would it be advisable to install forced draft equipment?

F. S. R.

Forced Draft Fan or Higher Stack

ON PAGE 407 of the April 15 issue, there appears under the caption, "Forced Draft Fan or Higher Stack," this startling statement: "This tendency (of burning out of holes in the fire where forced draft is employed with ordinary grates) is so well recognized that no attempt is made to burn small sizes of anthracite except on pinhole grates. . . ."

The reason for my surprise is found in the fact that I have burned anthracite dust mixed with bituminous coal for more than 16 yr. on dumping grates that have ½-in. iron and ⅜-in. air spaces. There are always some lumps of soft coal and aside from these the mixture is as fine as any fuel except pulverized coal. It frequently evaporates more than 9 lb. of water per pound of the mixture. It was introduced to eliminate the smoke nuisance and it has dispensed with 95 per cent of it. The cost is almost exactly one-half that of straight soft coal. This is quite an item when more than 2000 T. are burned per year. No more help is required, and my present firemen have burned it for more than 8 yr. and have become experts at it. When we had stationary grates, it required 7 min. to clean a fire but with dumping grates they do it in 3 min.

The author of this comment also makes the statement that the blower would develop a pressure in the furnace resulting in rapid deterioration of the furnace brick work.

Before I had experience with blowers, I had the same mistaken idea about the destructive effect of blowers in connection with brick furnaces. They can be turned into engines of destruction, but that they are necessarily so is not correct. This is the conclusion that I have arrived at after 18 yr. experience.

I formerly employed a mason to repair my furnaces but for 8 yr. the repairs were all made by my head fireman and he could not have done the work if extensive repairs had been necessary. I have 6 tubular boilers. Some of them have been used for several years, absolutely without repairs. Others have required slight renewals but none have been entirely rebuilt at any one time.

New Haven, Conn. W. H. WAKEMAN.

Heating of Turbine Blades While Running Idle

IN THE Jan. 15 issue, R. A. Woods attempts to furnish information in regard to the heating of turbine blades while running idle. This appears to be a question of considerable importance and one which many engineers operating turbines do not understand, as was evidenced by an engineer of 20 yr. standing who said to me the other day: "Can you imagine cooling a turbine with steam? Why, I had always thought we used steam to heat a turbine!" And so we do but that statement showed him ignorant of the principle and theory of the thermodynamics of liquids and gases under certain conditions.

This condition frequently occurs, especially in mills and factories where the power load is practically zero between 12:00 and 1:00. When the power is supplied by two or more alternators running in parallel, one of the turbines having a governor more sensitive, perhaps, than the others, takes the lead and admits steam to the turbine under its control, while the other alternators function as synchronous motors and continue revolving with power supplied by the leading unit. The spindle blading is rotated at a high speed, producing a windage which causes the blades to heat.

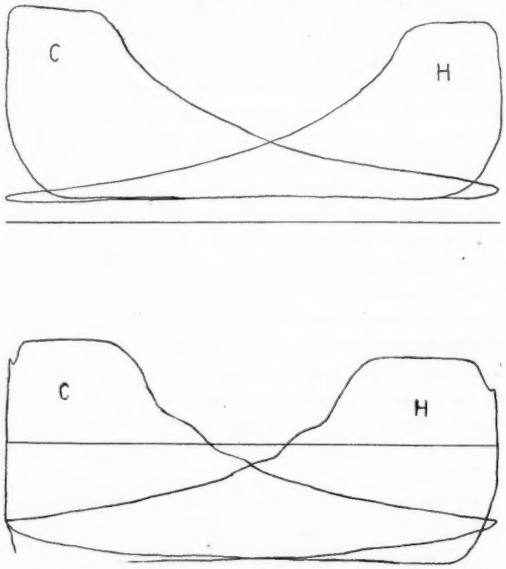
Now Mr. Woods suggests bleeding air instead of steam into the turbine, which only make matters worse, as the admission of air would destroy the vacuum to a certain extent causing greater friction, resulting in more heating of the blades.

There are only two remedies for operating under such conditions, either the admission of steam in sufficient quantities to keep the blading cool or if this cannot be done, the blades must revolve in as perfect a vacuum as it is possible to obtain. If the vacuum corresponds to an exhaust temperature of 100 deg. F. or less, the turbine can be revolved indefinitely without danger of blade heating.

New Bedford, Mass. R. G. SPOONER.

What Causes the Hook?

THE ACCOMPANYING indicator cards were taken from a 15 by 26 by 36-in. cross compound condensing engine which had recently been rebored and had new pistons and valves fitted. What can be done to improve the operation?



WHAT CAN BE DONE TO IMPROVE THESE CARDS?

What causes the hook on both low pressure admission lines? The boiler pressure is 100 lb. gage, the receiver pressure 10 lb. and the vacuum 25 in. of mercury. The speed is 100 r.p.m. J. L.

Mechanical Advantages of Hoisting Equipment

IT IS desired to raise a section of steel stack weighing 1000 lb. by means of a block and tackle with a double sheave block attached to the shear legs and a single sheave attached to the stack. The hoisting rope has a fall around a 10-in. diameter drum on the ground. A 24-in. gear on the drum engages a 6-in. pinion on a shaft which is fitted with a 12-in. crank.

1. What is the stress in the upper sling when the load is being raised, allowing 16 per cent for friction loss, viz.: 10 per cent on the sheaves and 6 per cent on the drum gearing?

2. What force is required at the crank handle to keep the stack clear of the ground?

3. What force will have to be exerted at the crank handle when the stack is being raised?

L. C.

ANSWERS

1. When the load is being held at rest, off the ground, the stress in the supporting sling would be equal to the weight plus the pull on the hoisting cable. With an arrangement as described the static tension in the cable is equal to the weight divided by the number of strands of

cable connected to or passing around the lower sheave, in this case $1000 \div 3 = 333$ lb. When the weight is being raised at a slow speed such that the acceleration has no appreciable influence the effect of the friction of the sheaves would be to increase this tension by 10 per cent to 367 lb. and under these conditions the stress in the sling would be 1367 lb.

2. When the weight is at rest, the tension at the hoisting drum is 333 lb. and the tooth pressure on the gears is $333 \times 10 \div 24 = 138.5$ lb. The force required at the handle is $138.5 \times 3 \div 12 = 34.6$ lb.

3. When the weight is being raised, the force will be increased by friction to $34.6 \times 1.16 = 40.2$ lb. If the stack were being lowered, the restraining force on the crank handle would be reduced by the amount of the friction to $34.6 \div 1.16 = 29.8$ lb.

Reasons for Horizontal Turbine

DEVELOPMENT OF modern steam generating sets seems to have left step-bearing equipment in the rear. Having been an engineer in plants that were equipped with the latest of both the horizontal and vertical type machines, it has always interested me to know just why the modern trend has, without exception, done away with the latter.

From the standpoint of the operating engineer, I do not think that much doubt remains that the vertical steam turbine is far more satisfactory than the horizontal type. In the first place, a vertical machine is always ready for a quick start up. This, next to economy, is one of the most important factors in the average central station, as it is often necessary in emergencies, to get a machine on the line and get it on quickly. Besides, after the machine is carrying the load it is possible to give it the full capacity almost instantly; while in the new machine such procedure is dangerous to say the least.

Leaking throttles have no terror for the old machine, for if steam leaks into the turbine casing while the unit is shut down, it rises to the top, which is the intended hot end of the casing, and the rotor is heated equally around its entire circumference.

It is also possible to turn on the steam seal with impunity and put a vacuum test on the condenser. Of course, it is possible to do this with some horizontal machines of small capacity but it is hardly advisable. Many engineers will boastfully state that they can do this with a horizontal machine but it has been my personal experience that they should be handled with great care at all times if one wants to keep out of trouble. In the past year, I have observed from time to time, some of the latest of the new 35,000-kw. units about New York City and the stations that have avoided trouble are the ones that have an iron-clad rule that the machine shall (except in extreme emergencies) be started and brought up to speed in no shorter time than 45 min.

Another dangerous thing that can happen to a horizontal machine and finally result in considerable damage, is the sudden dropping off of the load, or holding of the load far below its normal capacity for any length of time. Still another circumstance that may cause damage is the sudden loss of vacuum. All of these things have no vital effect on the old vertical machine.

Is it not possible to improve the vertical machines and make them as efficient as the new ones?

Another question for which I have been on the lookout for an answer concerns the heating up of the steam end of a turbine when the unit is operating as a synchronous condenser and no steam admitted to the blading. Practical experience determines that this is the case. What is the theoretical explanation? If windage is the cause, why does the steam end heat up when there is a fair vacuum on the turbine? Practical experience has shown that a certain amount of steam must be admitted to the turbine, regardless of the vacuum maintained. J. U. M.

A. From a commercial viewpoint, the question of the vertical type of turbine is answered by the fact that they are no longer built. This is due to a number of reasons, chief among which are the troubles which often developed with the step bearings, difficulty of balancing and maintaining the balance of the rotative element and constructional obstacles encountered when it was attempted to build the vertical machine with a large number of stages. This latter feature was desirable from the viewpoint of obtaining a steam economy equal to that of the present multi-stage horizontal turbine.

Other disadvantages of the vertical type were that the generator was placed directly over the turbine where it was subjected to excessive temperatures and damage from steam leaks; further, the machine was built as a unit and was therefore difficult to get at and dismantle when repairs were required.

Economy in the use of steam is of paramount importance in turbine practice. The old vertical units were built in not over five stages. To get the same economy which is available from the horizontal machine, it would be necessary to add stages to the vertical machine in which case a much longer time would be required to warm up the vertical unit. In fact, there would be no appreciable difference in starting up time between an old five-stage vertical turbine and a horizontal turbine of the same number of stages.

Vertical turbines were built in much smaller units than those ordinarily employed in present day practice, therefore, the weight of metal to be heated was formerly smaller and would take less time than to heat the greater mass which constitutes our present units. It is not uncommon to find horizontal units of 5000 kw. and even up to 10,000 kw. put on the line in not much more time than is required to assure the operators that all auxiliaries are working satisfactorily. This same precaution would have to be taken with the vertical machine.

Leaking throttles should be the exception in any plant and for any type of machine, this is a maintenance job which should be performed as soon as an inspection discloses that the condition exists.

When operating as a synchronous condenser or at extremely low loads a turbine will heat up. This is due to windage in both cases. At low loads, there is not sufficient steam passing through the turbine to keep the blades cool. Even with a relatively high vacuum on the condenser there is some air still in the turbine casing. The churning of this air by the turbine blades results in heat being generated due to friction between the air and the blades. There is danger of a turbine heating from this cause when the load drops below 25 per cent of rating.

It would no doubt be possible to build greatly improved vertical machines which would compare favorably with the horizontal type. The manufacturer is, of course, influenced by the demands of purchasers for economy, reliability and accessibility. These three points have established the popularity of and demand for the horizontal type of turbine.

Condensate from the World's Power Plant

ANALYZED FOR QUICK STUDY AND COMPARISON. BY WILLIAM SIBLEY.

Where "Back to Normalcy" Has Landed Us

Tennyson allowed his "Lotus Eaters" to cry:

"We have had enough of action, and of motion we,"
"What pleasure can we have to war with evil?"
"There is no joy but calm."

Had Tennyson been alive during 1919-20, he could not have penned lines more descriptive of the then existing mental state of the American people. Four years ago the American people, generally speaking, were weary and sick of war. They were anxious to rest their over-strung nerves. For the most part they were bored and impatient with the talk of "ideals," "duty" and "principles."

Recognizing this those clever students of human nature, the practical politicians, offered "Less government in business—more business in government" and gave promise of a return to normalcy. And that meant, so far as the people were concerned, a lower range of feeling, less diligent effort—to rest on the oars. And it was this unvigorous, undirected, too-soft characteristic on the part of government and people that permitted unscrupulous politicians and grasping "friends" to get into position where they could do things which have recently changed Congress from a legislative body to a glorified grand jury.

Have we learned our Lesson? We know now that you, I, and every other voter—the great American public—are to blame for the oil scandal, the alleged duplication of government bonds, etc. *We* lowered our ideals, our range of feeling. *We* thought there was "no joy but calm." *We* had had enough of "war with evil." *We* wanted to rest on our oars, to drift with the stream, to ease our taut nerves. *We* wanted to go *back* to normalcy. We did. And here we are—at our destination—all of us to blame. No doubt we are Lotus Eaters now as four years ago, the difference being that our Washington scandals and investigations have supplanted war activities.

There remain three things to do. First: Punish the guilty so severely that they be made unforgettable examples for posterity. Second: See to it that the more radical element does not take advantage of the present situation to further shake our faith and trust in our government, then use that lack of confidence to its own gain. Third: Resolve never to go *back* to anywhere. Onward—forward! And the only way we may feel certain we are going in the right direction is to take an active, personal interest not only in elections but in year 'round government business.

Fifty Dollars a Minute

During 1923 the maintenance of Congress cost the American tax payer $48,000,000. With the usual six-month period this is a cost of about $32,000 a day. Assuming that our legislators work ten hours a day, that means $3200 an hour—$50 a minute. It is not likely that Congress will cost less during 1924.

More than four months have now slipped by with little constructive legislation enacted. If we don't see to it (by personal letters to our representatives and senators) that Congress gets busy *soon,* we will have gotten little for our fifty dollars.

Our Diplomatic Service Could Be Bettered

Since this nation was first called upon to establish ambassadors, ministers, consuls and consulates, we have enjoyed an international reputation for providing the most under-paid and poorly-housed consular service of any world power. That this reputation is well founded there is no doubt. That this reputation has seriously hampered the effectiveness of our service, has frequently prevented capable men from entering the service and has reflected itself detrimentally in our international and foreign relations, is also true.

The Rogers bill, which passed the House last session and is now before the Senate, would do much to reform our diplomatic service and place it on a higher plane. It proposes, for instance, to pay those in service, salaries that, while not comparable to substantial successes in commercial pursuits, do provide a modestly decent livelihood. Secretaries are to receive salaries ranging from $3000 to $9000 annually. This is a change which will encourage a great many men, who are superior to those now employed, to enter the service. Salaries of the Ministers and Ambassadors, which range from $10,000 to $17,500, will not be changed. The bill provides, however, that they be suitably housed in government-owned homes and that they have a special fund from which to draw to cover the expenses incident to entertainment and social functions which are naturally concomitant with the position of a diplomatic officer. Furthermore, all members of the force will be made eligible to a retiring allowance after 10 yr. active service, thus removing the haunting fear of a penniless old age.

The British Ambassador to the United States receives a salary of $97,333. His government also provides a most imposing embassy, completely furnished. He is the highest paid diplomat in the world. Thus even though the Rogers bill advocates putting our service on a much higher plane and raises the salaries of many, it is still less lavish than several other countries.

The change proposed will involve an additional expenditure of about $300,000 a year. This increase, it is said, can be readily absorbed by the increased effectiveness of our diplomatic corps, as it is pointed out that in 1923, from an expenditure of about 8½ millions of dollars for consular service, receipts turned back to the government totaled nearly 8 millions, thus leaving less than one-half million to be paid by the tax payer. Indeed, in certain years, our consular service has actually yielded a profit.

From a financial, moral and psychological standpoint, the Rogers bill should be given a fair trial by the nation.

Have We Splendid Isolation?

What has become of the "splendid isolationist"? Where is he who scoffed the automobile, saying that it would never be more than a "toy for the rich"?

The automobile has become a recognized instrument for commercial and social progress, and is here to stay. The United States is in Europe and will continue to have

interests there, whether we like it or not. It cannot be otherwise. The world is not as large as it used to be.

If the earth was 25,000 miles around in the days of Columbus, its circumference today is only 4,100 miles, for we are crossing the Atlantic ocean in 6 days instead of 30. Messages can be sent from St. Louis to Paris, by wire, in 2 hr., whereas it took Washington a week to get a dispatch to Charlestown. A radio program broadcast from Chicago recently was heard in New Zealand and Australia in less than one second.

Through J. Pierpont Morgan, large credits to Germany and France have been established in American banks. These loans, the work of the Dawes commission, the settlement of the Memel question by Mr. Davis, the services of Mr. Morgenthau, and our constant though "unofficial" observers at the League of Nations, are merely straws that indicate the direction of the wind.

International Law and Common Sense

It has been said that we violated international law when we sold arms and munitions to the Mexican government. Not so long ago, we sold two old battleships to Greece—an action loudly protested by Turkey. Indeed, this act was logically protestable, owing to the strained relations then existing between those two countries. We dismissed Turkey's protest on the grounds that no war existed.

In Mexico war exists—but not between recognized nations. Rather, between a recognized government and a relatively small band of insurgents who have no diplomatic standing whatever. In selling munitions to the Mexican government we are only assisting a government which is making a desperate attempt to defend its ship of state from pirates. As a nation we can only ignore the protests of those who have no international standing.

Until a new day dawns in Central America, the United States should give her backing to the group which seems most capable of providing its particular country with an honest, stable government and fully support it against the bands of brigands and adventurers who plot an overthrow to the furtherance of their own end. This is an expensive way to be a big brother, but in the end our efforts will bring back dividends a hundred fold.

Tooth Brush Drills vs. Dentists

In a great number of grade schools the country over, teachers and principals are teaching the children tooth brush drill. The movement is good. It is doing much to prevent mouth and teeth disease.

In many ways various people are advocating peace—universal police force—limitation of armaments, etc. That also is good. It is doing much to educate people out of the idea of war, with all its attendant horrors and grief.

But there are people who go so far in this peace advocacy as to advocate complete disarmament—the rendering helpless of able bodied nations. They want to do away with the Citizen's Military Training Camps, the R. O. T. C., the Army, the Navy, and all kindred organizations.

And that is wrong. Just as wrong as to say, "Now that you are having tooth brush drill and are educating the children on mouth and tooth sanitation, we'll burn all dental colleges and abolish all dentists. We will throw all dental equipment in the river."

Water Power as Compared With Steam Power

ELECTRICAL energy is now being produced in many steam plants at less cost per kilowatt-hour than in many hydro-electric stations. Only a comparatively few of the hydro-electric stations of this country can successfully compete in low cost of generation with the large, modern, well-located steam plants of today.

This statement, as the rural electric service committee of the N. E. L. A. goes on to say, may seem absurd, since it is generally believed that water power always generates electricity cheaper than steam plants for the reason that steam plants burn coal and water-power plants do not. This reasoning is not sound, because it does not take into consideration all of the items of cost but only one, namely the item of fuel cost. There are other items of cost which, in many cases, more than offset the item of fuel cost and therefore must be given consideration.

Dam and power plant are nearly always built in a running stream of water and in most cases under unfavorable conditions, making the original construction cost high. The flowage pond usually covers many acres and the purchase of this flowage land is often a large part of the initial cost of a water-power plant.

To build, say a 10,000-hp. hydro-electric plant usually costs from two to four times as much as it costs to build a modern 10,000-hp. steam plant. Therefore, the interest and taxes on the hydro-electric plant will be from two to four times as much as the interest and taxes on the steam plant of like capacity. This extra interest charge and the yearly taxes on the hydro-electric plant may, in some cases, be more than the entire annual coal bill of the steam plant. Furthermore most streams vary a great deal between high and low water. During periods of high water the head of water at the dam is usually materially reduced and this decreases the available capacity of the plant during such periods.

On the other hand, during periods of low water, there is often insufficient water to run all of the generating units in the plant and this frequently reduces its output to a small percentage of its average output. This uncertainty of available power makes it necessary to have the water-power plant supplemented by a steam plant which can carry the load during these extreme low water conditions. This makes a duplication of investment in generating equipment and further increases the cost of the energy generated.

Efficiency of steam generating equipment has been so improved during the past 20 yr., that the consumption of coal per kilowatt-hour has been decreased from 12 lb. to 2 or 3 lb. and there is every reason to believe that better steam generating results will be attained in the future.

This increased efficiency of steam plants and high first cost of most water-power plants, together with the wide variation in flow in most streams, has brought about a condition whereby dependable electric power can in many cases be generated more cheaply in modern steam plants than in hydro-electric plants.

THREE HUNDRED years ago it was not impossible for anyone to acquire all the knowledge in the world. The advances we have made since then make it impossible so to concentrate the knowledge of the world in one human brain. Hence our age of "specialists."

POWER PLANT ENGINEERING

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Restricted Immigration Means Greater Power Opportunities

With our new policy of restricted immigration come certain problems of industry and of getting the work of the country done to which attention was called by Dr. Louis D. H. Weld in an address before the Chamber of Commerce of the United States at its recent Cleveland meeting. Limitation of immigration has for its basis primarily the need for unification of the country's inhabitants into a coherent nation, for the elimination of racial and language barriers and the establishment of American ideals and standards so that they may not be overthrown by introducing customs and practices of other lands until the original plan is buried among the additions. We need time to take stock of our growth and to consolidate our gains.

With this needed restriction come, however, certain economic and industrial problems. Great projects are under way and under consideration; building of roads, of railroads, of drainage and irrigation systems, of hydraulic plants, of public improvements, of industrial plants, and, as these are completed, arise problems of upkeep and operation. Lessened immigration will mean a slowing down in the growth of population, a lessening of man power available for construction and operation. If we are to continue our industrial growth, some way must be found to offset this loss.

During periods of slackened activity, the result will be less unemployment but what of the rush periods when, even now, there are more jobs than workers?

Dr. Weld pointed out three possibilities: Better management, eliminating some of the 50 per cent waste effort for which the Hoover Committee showed that management is responsible; new processes and better use of machinery to make man power more effective; better use of man power by fitting men to and for their work and by distributing workers in location and in industries according to the needs of the industries.

All of these point to the increased use of power. Better management will provide power-operated machines to replace hand labor, simplified and standardized product and interchangeable parts (machine made to a large extent) to reduce manual labor in manufacture and distribution. Fitting men for their work will mean better training which leads to higher grade workers able to use power-driven machines effectively. Distributing workers so that their work will be most effective means putting them where their manual labor can be best supplemented by power and introducing mechanical and electrical power to take the place of muscular energy where there is a shortage of workers, as well as to multiply the product of those at work. Making work more interesting is one of the surest ways to increase the efficiency of workers and a smooth running, efficient, power-driven machine is one of the most effective means of accomplishing this.

After all this is done, there will still be a great need for man labor, so that, as Dr. Weld pointed out, restricted immigration will affect the demand for workers much as the protective tariff affects prices on materials and manufactured goods. We shall maintain a high level of wages, prices and living standards as compared with other countries. This will work all right as far as we consume our own products, but, in competition for foreign markets, we shall be at a disadvantage, unless the higher wage cost is

offset by greater productiveness per man-hour. Use of power to assist production and the loyalty of the worker to his job are the most evident means toward this greater productiveness. The first of these is evidently up to the engineer in his professional capacity. To foster the spirit on which the second depends is a part of the engineer's work as a man and a citizen.

Three Steps Forward

It would seem, with the completion of each new power station, that a time had come when radical changes and improvements in design had reached the ultimate and that the plant which is announced today would follow closely the design of its predecessors.

This, however, is not the case, as is evidenced by the description in this issue of the new central station which is just being completed by the Detroit Edison Co.

But a short time ago there was introduced the double-ended boiler which was virtually two boilers in one. A little later the water screen followed as a natural development in the design of powdered fuel burning furnaces. Today, the Detroit Edison Co. not only uses a double-ended boiler but splits its water screens into two separate steaming units, fed through separate regulators and discharging steam into the steam space of the main boiler units. The result is that they have three separate boiler units within each furnace setting.

In 1908 Dr. F. G. Cottrell developed and put into practical use, in the mining and cement industries, his method of electrical precipitation of solids from gas. The engineers of the Detroit Edison Co. have adopted this method of eliminating from the air the objectionable flue dust resulting from the combustion of powdered fuel. Electrical precipitators have been placed between the induced draft fans and the boiler stacks.

Departure from conventional design did not stop at this point for, projecting above the roof of this new station, the observer will find the Venturi type of stack in place of the ordinary cylindrical type. The contour of the Venturi stack is similar to the outline of the Venturi tube such as is used in the measurement of gas and liquid flow.

Credit must reflect upon the engineers who have had the foresight to apply these three features which may be considered as three steps forward in power station design.

Automatic Substations for Industrial Systems

One of the most interesting developments in the field of electrical engineering during the past few years is the automatic substation. Although still a "baby" when compared to some of the older members of the electrical family, the automatic substation has made a good showing and is fast becoming an important element in the up-to-date transmission and distribution system. In fact, it has proved itself to be a rather "husky baby."

The idea of the automatic substation is not new. It is the natural result of development and perfection of automatic control apparatus for electrical machinery. Until the advent of automatic starting equipment for synchronous motors, converters and similar apparatus the automatic substation was an impossibility. Once this starting equipment was available, however, it was merely necessary to combine the several starting devices in order to produce the first rough semblence of an automatic substation. In late years development along these lines has been extremely rapid and improvements are constantly being added to the automatic devices available so that the scope of the automatic operations which may be obtained is constantly coming nearer to meeting all of the varied requirements of modern electrical operation.

While the automatic substation has given satisfaction and has been widely used in the central station and railway field, it has not received much attention from the industrial field, in spite of the fact that in this field the possibilities of success are most promising.

Readers interested in this subject will find the automatic substation discussed in the article by Chester Lichtenberg appearing in this issue.

Scale Deposit at High Ratings

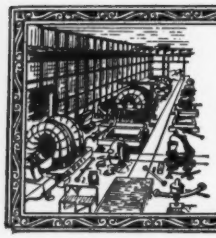
Determination of the suitability of a given water for boiler feed purposes depends not alone upon whether the water can be successfully treated to reduce its scale forming properties, but also upon the rating at which the boilers are to be operated. It has been shown time and time again that certain waters which will give no trouble that cannot be readily overcome with a boiler operated at ordinary ratings, will cause difficulties at higher ratings out of all proportion to any advantage secured by an increase in the power that a certain amount of heating surface may be made to produce. This consideration is one which is often overlooked when the redesign of a boiler plant calls for units which are to be operated at high ratings.

All natural waters contain some impurities which when introduced into a boiler may appear as solids. In most instances it will pay to treat the boiler feed water although the fact must not be overlooked that there are some waters which should not be used for boiler feed purposes and which no reasonable treatment can render suitable for such a purpose.

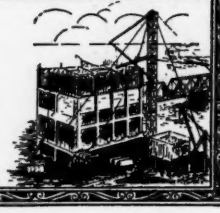
Ordinarily a feed water containing but 7 gr. of solids per gal. may be considered a good feed water. A study of this water from the viewpoint of total solids deposited over a stated period of time will throw a scare into any conscientious engineer. This water used in a 500-hp. boiler operated at rating for a period of one month, would deposit 1500 lb. of solids. If that same boiler were operated at an average rating of 200 per cent, the solids deposited would, for the same period of time, amount to 3000 lb. A water containing 20 gr. of solids per gallon would deposit in this boiler over 8500 lb. of solids under the conditions of the higher rating and during the same period of time.

It cannot reasonably be expected that a boiler will operate free from scale and priming troubles with even the lower content of solids present in the feed water. Blowing down the boiler at frequent intervals will not solve the problem, because the hard scale forming solids will continue to build up on the heating surfaces and a large portion of the suspended solids cannot be gotten out of the boiler except by completely draining and washing it.

Feed water treatment must be resorted to, first to break down the hard scale forming solids and secondly to precipitate out at least the greater portion of solids so that they will not enter the boiler. The importance of these facts is greatly amplified as the rating at which boilers are operated is increased.



POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS



Heating Plant at Pittsburgh Has Record Boiler

PULVERIZED COAL FIRED CROSS DRUM BOILER WITH 32,750 SQ. FT. HEATING SURFACE. SIDE WALL COOLERS USED IN ADDITION TO HORIZONTAL WATER SCREEN

AMONG the many new plants which are now under construction is one which is being built at Pittsburgh by the Allegheny County Steam Heating Co. which combines two features of particular interest. First, the plant is designed purely for the distribution of high pressure steam for industrial and heating purposes and, second, the one boiler which is now installed has a heating surface of 32,750 sq. ft.

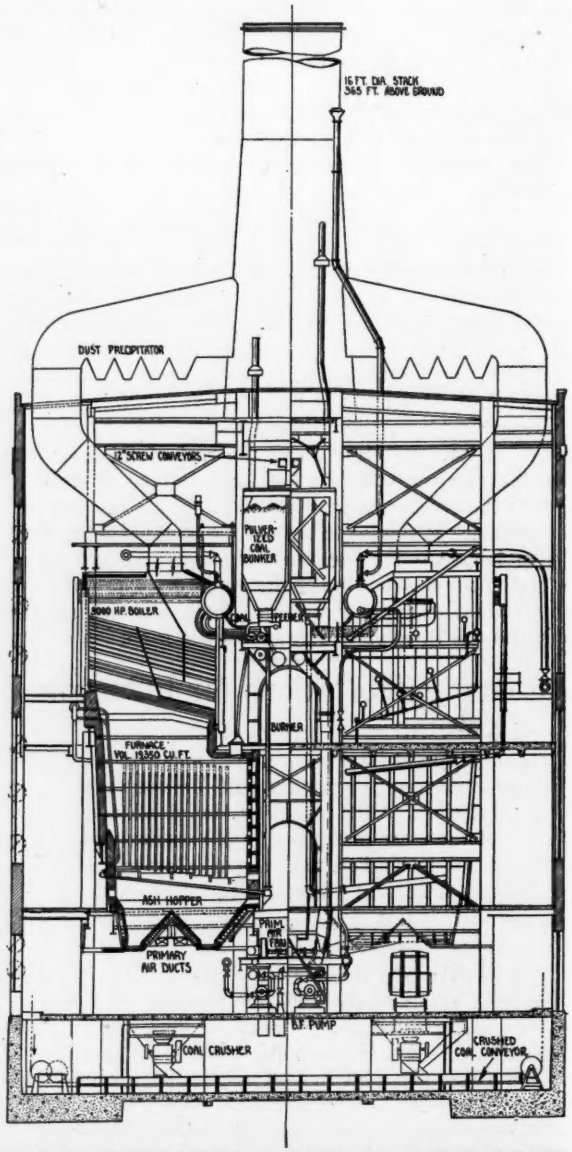
It will be noted from the sectional view of the station that this is a pulverized coal fired installation; that the boiler is of the Babcock & Wilcox cross drum type and that the side walls and the rear walls of the furnace are protected by a water screen in addition to the water screen which cools the ash as it drops through to the ash hopper.

Coal from the river or rail is brought into the plant on belt conveyors through a tunnel and put through coal crushers, delivering to a ring type bucket conveyor. This conveyor encircles the plant vertically and discharges the coal to the crushed coal bin located directly overhead. From the crushed coal bunker the coal drops by gravity to the pulverizers, from which it is taken by the exhauster fans and delivered to the collectors above the duplex screw conveyors which discharge into each of the pulverized coal bins.

For the first boiler unit the pulverized fuel equipment consists of two Raymond six roll, low-side, impact pulverizing mills, each with a capacity of seven T. per hr.; two No. 12 Raymond mill exhaust fans; two Raymond cyclone collectors; two screw conveyors and two eight-unit coal feeders. The pulverizers are driven through gear reduction by 100 hp. constant speed, 435 r.p.m. induction motors. From the pulverizers the coal is taken by two Raymond special exhaust fans, each driven by a direct connected induction motor, 50 hp., constant speed 1160 r.p.m., which deliver to the collectors. The collectors are located above the conveyor and are of the cyclone type.

Two 12 in. screw conveyors 58 ft. long, each driven by 5 hp., constant speed 870 r.p.m. induction motors, remove the coal from the bottom of the collectors and deliver it to the pulverized fuel bins. In order to obtain the maximum flexibility, cross connections with suitable valve arrangements are made so that any collector can discharge coal through either screw conveyor into any of the pulverized coal bins. The conveyors may be operated singly or together at a constant speed of 93 r.p.m. A storage capacity of 135 T. of pulverized coal is provided for each boiler.

From the pulverized coal bins the coal is fed to the furnaces by two sets of 8 unit Lopulco feeders driven by two 15 hp. constant speed 1160 r.p.m. induction motors through a No. 13 "Llewellyn" variable speed transmission and connected by a chain drive. The speed may be varied from 143 to 715 r.p.m.



SIDE WALL TUBES IN FURNACE ARE PLACED FLUSH WITH THE WALL SURFACE

As will be noted from the illustration, the furnace construction is of the hollow wall type, in which the side walls are 22½ in. thick and the rear wall, which is inclined, is 18 in. thick. The front wall is 25½ in. thick and is composed of 9 in. of standard fire brick, a 12 in. air belt, 4½ in. of hard Sil-o-Cel and a steel casing.

Construction of Water Screen and Coolers

As previously mentioned, the side and rear walls are protected by the installation of water cooling tubes. The side wall coolers are each composed of 17 4-in. tubes, approximately 31 ft. in length. The bottom water screen over the six ash hoppers is composed of 30 4-in. tubes, 29½ ft. in length each connected through a separate V-shaped elbow fitting, designed especially for this job, to corresponding tubes which shield the rear wall. Both the side wall coolers and the water screen tubes are supplied from water taken from the main steam drum down through 8 in. pipes to forged steel headers located around the base of the furnace. The tops of all tubes are connected to headers of the same type, placed outside of the furnace wall in an inclined position, the upper ends of which are connected to risers, which in turn are connected to the main steam drum.

The cooler tubes are set flush with the inside surface of the furnace, so that they will slag over and present a full refractory surface to assist combustion. They are so located that the strength of the brickwork and steel casing and structure will be thoroughly protected.

While the water used in the water screens and wall coolers is taken from the boiler, an independent system of circulation is used, and the connections to the drum are so arranged that the water in the main heating surface cannot be drained through any failure of the water screen or side wall cooling tubes.

With this design an effective furnace volume of 19,350 cu. ft. is obtained, while the volume of the space beneath the water screen, which comprises the ash hopper, is 4000 cu. ft.

Sixteen Lopulco type fantail burners are mounted in a Liptak suspended arch, at the top of the furnace. The burners are slightly pitched away from the front wall of the setting so that the likelihood of flame impingement will be minimized.

Air Supply for Combustion

About 10 per cent of the air required for combustion is supplied by two Sturtevant fans at a pressure of 15 in. of water, each having a capacity of 7500 cu. ft. of air per minute. Each fan is driven by a 60 hp. constant speed 1750 r.p.m. induction motor. These units are placed on a balcony floor over the ground floor and the air, heated in the ducts around the ash hoppers, discharges to an air header, hung below the fourth floor. The primary air is taken from this header through the Lopulco pulverizer coal feeders.

Secondary air is admitted through 128 openings in the front wall controlled in eight separate horizontal zones by air doors fitted to the intake ends of the air passage at the two sides of the boiler setting. These doors are operated from the operating floor. The shape and direction of the flame is thus under the control of the operator.

As previously mentioned, the total water heating surface of the boiler is 32,750 sq. ft., which includes the side wall coolers and the main water screen over the ash hoppers. The side wall coolers have 734 sq. ft. of heating surface. The rear wall coolers 890 sq. ft. and the horizontal or slag screen 760 sq. ft. The present working pressure is 150 lb. per sq. in. but all the equipment is designed for a future pressure of 190 lb. The normal evaporation is 103,100 lb. per hr., the continuous evaporation 309,300 lb. and the maximum evaporation 412,400 lb. per hr.

In this boiler the cross drum is 34 ft. long with a diameter of 60 in. and a plate thickness in the shell of 11/16 in. and in the heads of 7/8 in. The baffles are Babcock and Wilcox tile type, installed inclined to make three passes. There are 1173 4-in. No. 9 B.w.g. boiler tubes, 24 ft. long. These are arranged 51 tubes wide and 20 tubes high with three additional rows of circulating tubes. Steam is delivered into the header through two steam outlet nozzles of 10 in. internal dia. Fourteen 4½ in. safety valves arranged in pairs on seven openings on the drum have a popping pressure of 200 lb. per sq. in., and supply adequate protection. Since this boiler supplies steam for heating service, no superheater is used.

Approximately 75 per cent of the water used in the boiler is condensate and 25 per cent Allegheny River water. This feed water is heated to a temperature of 210 deg. in an open feed water heater, at present located in the basement of the adjoining Duquesne building. The water is pumped to the boiler by a three stage Buffalo centrifugal pump. This pump when operating at a speed of 2100 r.p.m. is capable of delivering 1000 gal. of water per minute and is driven by a direct connected 225 hp. Terry steam turbine.

Water is supplied to either or both ends of the drum at a pressure of 250 lb. per sq. in. The water level in the boiler is controlled by Copes feed water regulators and Williams water columns are used on the boiler.

Water to the boiler is measured with two Simplex water meters which include one 6 by 3¼-in. bronze throat venturi tube of a maximum capacity of 325,000 lb. per hr. and one 3 by 1¾-in. bronze throat venturi tube of a maximum capacity of 95,000 lb. per hr. These two meters give a complete record of the feed water input.

Steam flow, air flow, flue gas temperature and coal feeder speeds are recorded by a four pen Bailey boiler meter. A Bacharach electric CO_2 indicator and a Bailey four pointer draft gage indicating pressures of furnace draft, uptake draft, stack draft and the primary air, are a part of the equipment.

Other instrument equipment includes two 12-in. steam pressure gages for indicating drum and line pressures; one 12-in. Foxboro recording thermometer for measuring feed water temperatures and one 12-in. Foxboro recording pressure gage for recording steam pressures and feed water pressures. All of the above instruments are grouped on a central board near which the draft and coal feeder controls are located. All electrical equipment is operated by distant control relay apparatus and can be operated either at the central point or at the machine.

To keep tools from rusting, melt half a pound of lard; add a half ounce of camphor, stirring well and skimming off the scum; then stir 3 oz. of finely powdered graphite into the melted lard and camphor. Clean the tools, wipe them dry and smear them with this hot mixture. After 24 hr., any surplus of the grease on them can be wiped off with a cloth or clean waste.

New Flexible Coupling Uses Laminated Springs

TWO NEW types of Francke flexible couplings have recently been placed upon the market by Smith and Serrell of Newark, N. J. The type shown in Fig. 1 is a new high-speed coupling for turbine and motor drives while that shown in Fig. 2 is a pressed steel coupling designed for fractional horsepower motor drives of from about ¼ hp. up to 1 hp. at 1800 r.p.m. and for shafts anywhere up to ¾ in. diameter.

Couplings operating at extremely high speeds need to be made of steel and in the case of high-speed motor and turbine drives lubrication is usually necessary to provide

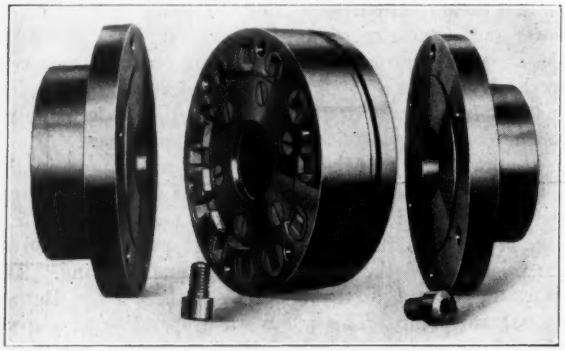


FIG. 1. NEW FRANCKE HIGH SPEED TYPE FLEXIBLE COUPLING

for easy endwise movement. Both of these requirements are met in the new Francke couplings. They are furthermore, easily accessible for inspection and repairs without moving either of the connected machines.

The principle employed in these couplings is illustrated in Fig. 3. A small bundle of flat steel springs serves to transmit power from the driving member to the driven

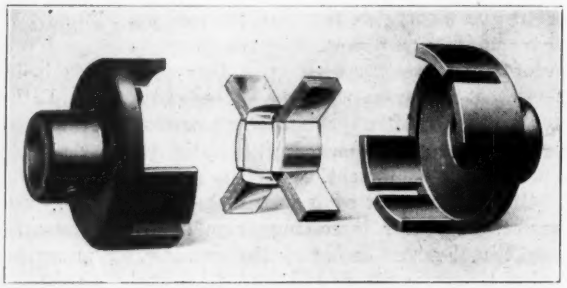


FIG. 2. PRESSED STEEL TYPE OF COUPLING FOR SMALL DRIVES

member. These steel springs can bend under comparatively small forces and can withstand continuously flexing back and forth without damage.

Referring to Fig. 3, the keepers in the outer member can rotate as well as slide endwise in this outer member. Thus the bearing between the bundle of springs and the keeper is constant, a surface bearing rather than line or point contact. The bundle of springs can slide in a vertical direction (or in a horizontal direction at 90 deg. from the position shown) so this type also provides flexibility in all directions.

As may be seen from Fig. 1, a number of such elements as shown in Fig. 3, are incorporated in a coupling in order that large amounts of power may be transmitted.

These couplings operate through a great range of speeds and on many kinds of installations. The lubrication requirements vary with the type of application. Grease lubrication is suitable for some drives and this type is built to retain grease or oil. On other drives addition of oil or grease may be desirable either when stopped or

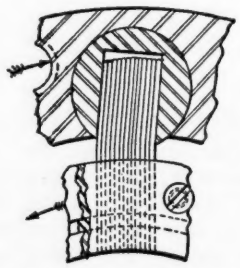


FIG. 3. DIAGRAM ILLUSTRATES PRINCIPLE OF ACTION IN FRANCKE COUPLINGS

while the coupling is running. In still other cases, continuous flood lubrication with fresh, clean oil may be provided from an outside source and by enclosing in an oil case.

The pressed steel type of coupling shown in Fig. 2 is a three part, all metal flexible coupling consisting of two similar pressed steel flanges and a center laminated spring cross. It is flexible in all directions as well as extensible endwise. It is quiet in operation, simple and durable.

Rubber Bearings for Centrifugal Pumps

RUBBER surfaced bearings have recently been placed on the market by the B. F. Goodrich Rubber Co., Akron, O. The principle involved in the construction of these bearings is that of automatic lubrication, which is accomplished with the liquid in which the bearing and its shaft are submerged.

Constructionally, the bearing is made up of an outer metallic shell, which is threaded on its inner surface. The rubber bearing liner is then moulded over a mandrel with this metal shell as a mould. A spiral groove is left on the inner surface of the rubber liner. The purpose of this groove is to allow the egress of foreign matter, which may be in the liquid being pumped and to provide a channel for the passage of a part of the liquid being pumped, which is the only lubrication that the bearing requires.

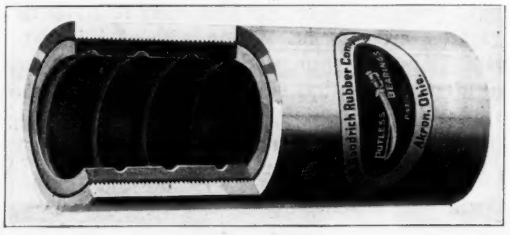
At the speed at which most centrifugal pumps operate the groove develops a decided pumping action so that when the spiral groove is designed to operate in the direction of the pump impeller, the liquid will be forced into the pump casing.

Two problems confront the builder and user of centrifugal pumping equipment; one is how to lubricate bearings simply, inexpensively and continuously and the other is how to secure a bearing that will not cut or score itself or the rotating member when used in a pump handling water containing grit or sand.

These problems are met by the rubber bearing in that it is lubricated continuously by a steady flow through the

bearing of a part of the liquid being pumped. When a piece of grit or sand gets into the bearing it cannot find lodgment in the highly resilient rubber but in impinging against the bearing wall, it is thrust into the groove, where the flow of water carries it away.

Tests have shown, during 144 hr. of pumping water which contained 25 per cent sharp beach sand, that not the slightest trace of cutting or scoring was evident on either the shaft or the bearing surface. Rubber surfaced bearings in deep well pumps have run over two hours dry without harmful results. The bearing is not recommended, however, for service of that kind. Rubber surfaced bearings



SPIRAL GROOVE IN RUBBER LINED BEARING FURNISHES PATH FOR WATER USED AS LUBRICANT

are as readily applicable to horizontal shaft pumps as to the vertical shaft type.

Wet and dark atmosphere under which these bearings operate is ideal for the prolongation of the life of the rubber. To change over an existing pump to the use of rubber surfaced bearings requires simply that the bearing housing must be approximately ¾ in. larger than the shaft. Due to the resiliency of the rubber surfaced bearings pump shafts equipped with them will operate with less vibration than if equipped with metal bearings.

In addition to bearings, the idea of rubber surfacing has also been extended to use on centrifugal pump sealing rings. These rings have proven successful both as to long life and effectiveness in maintaining high pump efficiencies over long periods of time.

New Station for Los Angeles Gas & Electric Co.

AS A RESULT of the rapid growth of the electrical business following the expansion of the city of Los Angeles, the Los Angeles Gas and Electric Corporation has started the construction of a new steam generating plant with an ultimate capacity of 200,000 kw. to assist in caring for the increased industrial and domestic load. The present generating station, which is located in the heart of the industrial section of the city, has reached its maximum capacity and has no further room for expansion. The site selected for the new station is at Seal Beach, about 25 mi. from the business district of Los Angeles, and at a point where tidal water can be used for condensation. A high voltage line transmitting power at 110,000 v. will connect the generating station with a receiving substation located at the edge of Los Angeles' industrial section, 20 mi. distant.

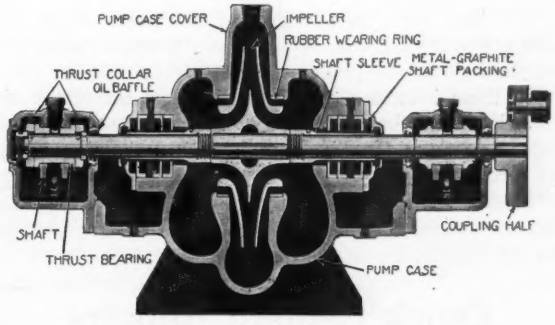
A steam turbine for operation at 350 lb. steam pressure with a 50/60 cycle generator having a maximum capacity of 35,000 kw. at 60 cycles has been ordered from the Westinghouse Electric and Manufacturing Co. for the new generating station. Since the Los Angeles Gas and Electric Corporation operates at a frequency of 60 cycles and yet is at times tied in with the systems of the Municipal Power Co. and the Southern California Edison Co., which operate at a frequency of 50 cycles, the equipment has been designed for operation at either of these two frequencies. In the present plant, this is being accomplished by slowing down the speed of one of the steam turbines and delivering power at 50 cycles to the Southern California Edison Co.

Power for use within the station will be supplied by a 1250 kv.a., 2400-v. generator direct connected to the turbine-generator unit. Two 200-kw. dual drive exciters and the complete control and switching apparatus complete the equipment in the generating station supplied by the Westinghouse Co.

Transformer equipment ordered by the power company consists of four 12,500 kv.a., single phase, 50/60 cycle, oil immersed, water cooled, indoor shell type step up transformers, 63,800 v. high tension; three 2000-kv.a. transformers for station power service; and three 12,500 kv.a. transformers for stepping down the voltage to 15,000 v. at the receiving substation. The 12,500 kv.a. step up transformers have full capacity taps to provide the full rated high tension voltage when operated from the reduced generator voltage which will result from 50-cycle operation. The high tension side will be star connected for 110,000 v. All of these transformers will be supplied by the Westinghouse Electric and Manufacturing Co.

Rubber Sealing Rings Feature of New Centrifugal Pumps

SEVERAL features of interest are incorporated in a centrifugal pump which has recently been placed on the market by the Moore Steam Turbine Corporation, of Wellsville, N. Y. Two outstanding features are the use of an improved rubber sealing ring on the impeller between the suction and discharge chambers, and the use of a metal graphite packing ring in the packing glands, instead of the ordinary flax packing.



METALLIC-GRAPHITE SHAFT PACKING IS USED

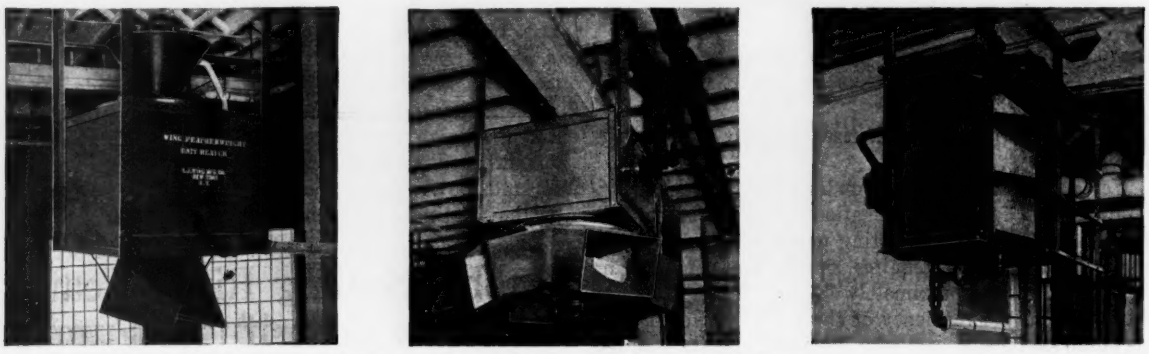
These metal-graphite packing rings rest lightly upon the revolving shaft and there is no binding effect to retard rotation. The packing is not affected by hot or cold water and once it is properly fitted, leakage is reduced to a minimum.

Moore pumps are horizontally split and use brass protected chrome nickel steel shafts. They are built single and multi-stage, for motor, turbine or belt drive.

Air Passes Through Tubes in New Unit Heater

ONE RATHER unusual feature of a unit heater, which has recently been developed, is the use of a heating element of seamless copper tubing. The air, however, passes through the tubes and steam surrounds them, as contrasted with heavy weight iron pipe coils in which the steam passes through the pipes and the air around the outside of the pipes. This form of construction is said to give a heater of extremely light weight and high efficiency.

Since heated air always rises to the highest point in the room, with the old method of heating there is nothing to prevent the heat from rising to the ceiling first, consequently its effect is not felt at the working level until it has lost considerable of its temperature. The unit heaters take the warm air from the higher levels, heat it and return it again to the working levels by mechanical means, thus completely heating the building in a short period of time.



THREE DIFFERENT FORMS OF THE UNIT HEATER

Where the ceiling is high the unit shown at the left is used. This type directs the air downward while the unit in the center, used on low ceilings, directs the air outward. At the right is shown the horizontal type. Another form, not shown, is for medium ceilings.

In addition there are other advantages cited for these heaters. Being located well overhead, they are out of the way of machines and workers, and leave a clear, unobstructed working floor. They leave the walls, where the light is best, clear for benches and machines. Since the units are overhead, dust is not drawn from the floor and distributed over the plant.

In these heaters a fan is employed to direct the air through the heating element and through the air outlets. Motors on these fans are completely ball bearing in all the vertical types.

Heaters of this type are built by the L. J. Wing Mfg. Co., of Newark, N. J., and are known as the Wing Feather Weight Unit Heater.

Quick Cement Repairs

FREQUENTLY it is desirable to make repairs on floors, pits, tanks and foundations without interrupting operation of the plant; or it is necessary to install foundations for machinery as quickly as possible. Cement is the most convenient medium for this work but, though it sets quickly, some time must be allowed for it to attain greatest strength.

French practice, during 12 yr., has developed a hydraulic cement made from materials containing a large proportion of aluminum ore, which is said to attain as great strength in 24 hr. as Portland cement attains in 28 days. It is used the same as ordinary cement except that mixtures are made rather wetter than with the Portland cement.

Lumnite, the American aluminous cement, does increase in strength with time, but it is said to set rapidly during the first day, later increase being gradual. Laboratory tests are reported showing for a 1-2-4 mix a strength of 3441 lb. per sq. in. after 24 hr., 4127 lb. after 3 days and 4462 lb. after 28 days; for a 1-3-6 mixture, the figures were, 2071 lb. per sq. in. after 24 hr., 2598 lb. after 3 days and 2691 lb. after 28 days. Examples are given of putting roads, bridges and heavy foundations into hard service after 24 hr. setting without injury to the concrete. Also for form work, the forms have been removed after 48 hr., thus effecting a saving in lumber on large jobs.

Process for making this cement is patented and works have been erected at Northampton, Pa., by the Atlas Aluminate Cement Co. for its manufacture under the patents of Colonel Henry S. Spackman, the inventor. The New York office is at 25 Broadway.

For locations where cement is exposed to chemical action, the Lumnite cement is said to have the added advantage of resisting the attack of sea water or sulphate bearing ground waters.

News Notes

FARLEY OSGOOD, Vice-President and General Manager, Public Service Electric Co., Newark, N. J., was elected President of the American Institute of Electrical Engineers at the annual business meeting held in the Engineering Societies Building, New York, Friday, May 16. Other officers elected were: Vice-Presidents—Harold B. Smith, Worcester, Mass.; L. F. Morehouse, New York; Edward Bennett, Madison, Wis.; H. W. Eales, St. Louis, Mo.; John Harisberger, Seattle, Wash.; Managers—John B. Whitehead, Baltimore, Md.; E. B. Merriam, Schenectady, N. Y.; J. M. Bryant, Austin, Tex.; Treasurer—George A. Hamilton, of Elizabeth, N. J. (re-elected).

These officers together with the following hold-over officers, will constitute the Board of Directors for the next administrative year, beginning Aug. 1: Harris J. Ryan, Stanford University, Calif.; Frank B. Jewett, New York; J. E. Macdonald, Los Angeles, Calif.; Herbert S. Sands, Denver, Colo.; S. E. M. Henderson, Toronto, Ont.; H. E.

Bussey, Atlanta, Ga.; William F. James, Philadelphia, Pa.; R. B. Williamson, Milwaukee, Wis.; A. G. Pierce, Pittsburgh, Pa.; Harlan A. Pratt, Hoboken, N. J.; H. M. Hobart, Schenectady, N. Y.; Ernest Lunn, Chicago, Ill.; G. L. Knight, Brooklyn, N. Y.; W. M. McConahey, Pittsburgh, Pa.; W. K. Vanderpoel, Newark, N. J.; H. P. Charlesworth, New York.

At the meeting of the Board of Directors held on the same date, F. L. Hutchinson was reappointed Secretary of the Institute for the coming administrative year.

The annual report of the Board of Directors, presented at the meeting showed a net increase in the membership during the year 1157, the total membership on April 30 being 16,455. In addition to the four general conventions of the Institute there were 911 meetings held by the local organization in the principal cities and educational institutions in the country, the aggregate attendance at these meetings exceeding 80,000.

THE FIRST CONVENTION of the Northeastern District of the American Institute of Electrical Engineers will be held at Worcester, Mass., June 4 and 5, with headquarters at the Bancroft Hotel. The two-day program has been arranged with a diversity of features to interest many members. Three excellent technical sessions have been scheduled besides a banquet and several inspection trips. The technical papers include such subjects as transmission, radio, insulators, temperature measurements, transformers for testing and windmill generators.

WORTHINGTON PUMP and Machinery Corporation announces the closing of its power and mining works at Cudahy, Wis. All lines of product formerly manufactured at this plant will be transferred to other works of the company except the mining, crushing, cement and creosoting machinery. The manufacture of the latter equipment has been transferred to the Allis-Chalmers Mfg. Co. which has taken over all of the records, drawings, patterns, patents, jigs, pictures and manufactured stock pertaining to these lines.

FRANK C. CALDWELL, a director of the Link-Belt Co. since the purchase of the H. W. Caldwell & Son Co., by the Link-Belt Co. in 1921, was stricken with heart failure the morning of May 15 while on his way to his bank. He died in an ambulance enroute to a hospital. Mr. Caldwell was born in Indianapolis in 1866, and came to Chicago in the early eighties to complete his education at Union College of Law. He practiced until 1892 when he became Vice-President of the H. W. Caldwell & Son Co. He became president in 1908 and continued until the Caldwell Co. was purchased by the Link-Belt Company in 1921.

WITH PRELIMINARY INVESTIGATIONS at the Pelton power site on the Deschutes River in Oregon completed, the Columbia Valley Power Co. is ready to start construction of the lower plant planned for that location. The company intends to construct a dam 140 ft. high to produce 60,000 hp. Eighteen months will be required to do this work and it is planned to have the plant in operation by January, 1927.

MAURICE PARSONS, for the past year and a half associated with Arthur D. Little, Inc., Cambridge, Mass., and for 4 yr. prior to that with Lockwood, Greene & Co., in its Atlanta, Georgia, office, is now engineer in the Structural Division of Stone & Webster, Inc., Boston. Mr. Parsons is a Stanford University graduate and has had varied experience in estimating, designing and construction on many large engineering projects.

Walter M. Stone, formerly a member of the engineering firm of Stone, Bigelow & Tirrell, of Boston, Mass., has joined the Structural Division of Stone & Webster, Inc., in its Boston Office.

Francis L. Searway, formerly with Dwight P. Robinson & Co., and more recently with Morgan & Morgan, of Boston, as Appraisal Engineer, has joined the Appraisal Division of Stone & Webster, Inc., in its Boston Office.

THE H. G. JARMAN CO., Farwell Building, Detroit, Mich., has been appointed representative of the Vacuum Ash and Soot Conveyor Co., of Newark, N. J., and will act as representatives for the entire state of Michigan and the City of Buffalo.

WITH THE OFFICIAL OPENING of the new Hudson Ave. Station of the Brooklyn Edison Co. on May 12, the largest single unit turbo generator in the United States was placed in operation. This machine is rated at 62,500 kv.a., 1200 r.p.m. and operates on 265 lb. pressure, 200 deg. superheat.

THE CONNECTICUT BELTING CO. was recently organized and incorporated for the manufacture of Oak Tanned Leather Belting at Norwich, Conn.

Officers and directors are, Ernest L. Baldwin, president and general manager; Francis H. Stager, vice president, and Stanley M. Kingsbury, secretary and treasurer.

L. D. ALBIN, formerly general sales manager of the Ingersoll-Rand Co., 11 Broadway, New York City, has been elected vice-president in charge of European sales of the company. D. C. Keefe, formerly assistant general sales manager, has been appointed to succeed Mr. Albin as general sales manager.

CONTRACT WAS RECENTLY placed by the Columbus Railway, Power and Light Co., Columbus, Ohio, with the Link-Belt Co. for a gondola car dumper. The specifications for the dumper calls for a mechanism that will capably handle 4000 T. of coal in an 8-hr. day, and which will accommodate gondola cars of 120 T. capacity. The new power and light station is being erected at Lockbourne, Ohio, about 14 mi. out of Columbus.

CONTRACTS have been let for a new electric power and distribution system at Fredonia, Kansas, according to an announcement by Arthur L. Mullergren, consulting engineer of Kansas City, Mo. The power-plant building and oil-storage tank has been let to the F. C. Randel Construction Co., Wichita, Kan., for $19,780; the Diesel oil-engine generating units, switchboard, and installation to the Worthington Pump & Machinery Co., Kansas City, Mo., for $61,375 and the distribution and street-lighting system to the Neben Brothers Electrical Construction Co., Muskogee, Okla., for $31,483.

Books and Catalogs

COKE AND ITS USES, by E. W. L. Nicol; 8 by 10 in., 134 pages, 31 illustrations; New York, 1924. Price $5.

Written by an English author, this book treats in detail the use of coke for power and domestic purposes, giving the real and imaginary troubles which have been encountered and the remedies for them. It describes the history of coke making, the various methods in use at the present time, and the effect of various constituents in the coal on

the qualities of the coke. Of special interest to power plant men are the chapters on Coke as Fuel for Steam Raising and Coke as Fuel for Electric Power Stations. In these are discussed the methods of handling coke and mixtures of coke and coal to the best advantage, special attention being given to the Sandwich method for firing coal and coke in stratified layers, which is a system devised by the author. In other chapters much more than the question of coke burning is taken up for the book deals with Influence of Excess Air, Forced Draft as a Factor, Smoke Prevention, Purchase of Fuel on a Calorific Basis.

The author is an advocate of coke and presents the arguments for its use. He has, however, treated the matter from an economic and engineering standpoint and has included much information which is important in considering what fuel to use. Three chapters are devoted to the domestic use of coke, showing how to use it to best advantage and the gain from such use. While written from the English viewpoint, it is a book well worth reading and one which will be found helpful in the use of what seems likely to become more and more a common fuel in the power plant.

MECHANICAL ENGINEERS' HANDBOOK, second edition, revised and enlarged by Lionel S. Marks, Editor-in-Chief and staff of specialists. XVII + 1986 pages, illustrated; water-proof Keratol binding; New York, 1924. Price, $6.00.

This year brings forth the second edition of Mark's Mechanical Engineers' Handbook. The present edition has been completely revised and enlarged, the method of doing this work having been the same as practiced in the preparation of the original, that is by a large number of specialists. The purpose of bringing this book out in its second edition is to have the data and information contained in it conform to latest practice and experience, to bring the book up to date so that information obtained from it will conform to modern engineering methods.

To do this it has been necessary first to condense and eliminate a considerable portion of the old text. The completed second edition contains approximately 150 pages more text than did the first edition. Manufacturers' tables have been used only for such products as are fully standardized.

Subjects which have undergone the most change in the new edition are hydraulics, heat, iron and steel, nonferous metals and alloys, bearings, steam boilers, internal combustion engines, aeronautics and air compressors. Among the more important of the new topics are drying and lubrication. The power test codes and similar material have been brought up to date.

The section on steam boilers is subdivided into the subjects; materials and construction, the burning of fuel, capacity and efficiency of steam boilers, boiler feed waters and economizers, brickwork, safety valves, chimneys, management and insurance. The section on internal combustion engines has been enlarged by over 50 per cent. The new chapter on lubrication covers the lubrication of special machinery such as steam and internal combustion engines, turbines, compressed air machinery, etc. U. S. Government specifications for lubricating oils are also given.

"WHEN THE DEAN GOES THROUGH!" is the title of a folder which is now being distributed by the Wm. B. Pierce Co., 45 N. Division St., Buffalo, N. Y. This folder shows the different types of cleaners which are built and also gives a sectional view of a cleaner showing how it operates.

INSULATING CONDUIT for underground steam and hot water pipes, condensation returns, fuel oil, etc., are covered in catalogue No. 6 issued by the Ric-Wil Co., Union Trust Bldg., Cleveland, Ohio. This scheme of pipe insulation is made up of tile, insulation and special methods of support.

IN A BULLETIN which has recently been issued by the General Electric Co., of Schenectady, N. Y., the Emmet mercury vapor process is described. Illustrations show the equipment which has been installed at the Dutch Point Station of the Hartford Electric Light Co., at Hartford, Conn., where a mercury boiler and mercury turbine are now in operation.

HEINE CROSS-DRUM BOILERS are covered in bulletin No. 53, recently published by the Heine Boiler Co., of St. Louis, Mo. Details of the boiler construction such as the use of box headers made up of two heavy steel plates with long-radius turned flanges at top and bottom, method of staying header plates by means of hollow stay bolts, forms of manhole closures which are used, types of baffling which are provided and other such details are presented.

CLEVELAND ELECTRIC TRAMRAIL CRANES are covered in catalogue No. 3 which has been published by the Cleveland Crane & Engineering Co., Wickliffe, Ohio. This is a series of bulletins which has been combined under one cover and which give a comprehensive discussion of the uses of tramrail cranes for material handling in different industries. The fields of particular interest to power plant engineers are the use of such cranes in ice plants and in the handling of coal and ash.

DUQUESNE COMBUSTION UNITS are described in Catalog No. 11, which is now being distributed by the Duquesne Burner Service Co., of Pittsburgh, Pa. This bulletin describes a new type of burner for use with gas or the burners may also be arranged for a combination of gas and oil. Each gas burner unit is made up of a large number of gas burners and the regulation is taken care of by one gas valve and one air slide. The design is said to cut down excess air to a minimum and to result in better combustion.

"QUITETITE" REDUCING VALVES and Koerting double tube injectors are described in two bulletins which have recently been issued by the Schutte & Koerting Co., of Philadelphia, Pa. The reducing valve is one which is designed for diaphragm control and which works within narrow control limits. It is stated that there are no sleeves or stuffing boxes to cause friction or irregular operation. The construction of the valve is covered, and some capacity curves are presented which show how to figure the proper size for the quantity of steam the valve is required to handle. The principles of operation of the double tube injector, which is a device for delivering hot water to steam boilers, is explained.

ALLEN-BRADLEY CO., of Milwaukee, is making a revision of its general catalog which is made up of a number of bulletins. Four of these bulletins covering Across-The-Line Starting Switches, Semi-Automatic Resistance Starters, Alternating Current Resistance Starters and Automatic Resistance Starters, are now available. The bulletin on Alternating Current Resistance Starters takes up the theory of the use of this type of starter in comparison with the use of a compensator. The bulletin points out its superiorities and gives the various arguments for their use.